ENGINEERING EVALUATION/COST ANALYSIS FOR EMPIRE CANYON

EPA ID No. 0002005981

July 8, 2003

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EXECUTIVE SUMMARY

This Engineering Evaluation/Cost Analysis evaluates the proposed response action alternatives for the Empire Canyon Site, EPA ID No. 0002005981, located approximately one mile south of Park City, Utah. An EE/CA is required under the National Contingency Plan (NCP, 40 CFR 300) for all non-time critical removal actions[1] under the Comprehensive Environmental Response, Compensation and Liability Act. United Park City Mines Company is conducting this Engineering Evaluation and Cost Analysis pursuant to an Administrative Order on Consent, dated May 14, 2002, U.S. EPA Region 8 Docket No. [CERCLA-08-2002-05].

The EE/CA is a streamlined focused document that provides site characterization data, assesses human health risks, evaluates ecological exposures, evaluates various response alternatives, recommends a preferred response alternative and provides a vehicle for public involvement.

Environmental investigations in Empire Canyon have reported elevated concentrations of lead and arsenic in waste rock, soils and sediments. Elevated concentrations of zinc and cadmium have been observed in surface water samples collected in Empire Canyon and Walker Webster Gulch (a tributary to Empire Canyon).

No human health Risk Assessment is included in the EECA. Human exposure concerns are being addressed through construction requirements within agreements with local government entities by covering or rerouting recreational trails. Ecological exposures were characterized using criteria appropriate for the hydrologic setting of Empire Canyon and the response action.

[1] The term "non-time critical removal action" is a legal term of art with a precise meaning under CERCLA and its implementing regulations. Because, however, the term may be unfamiliar to many lay readers and may give them a mistaken conception of the actions proposed or evaluated herein, the term "response action" will generally be used throughout this document when referring to such actions. This usage is consistent with the inclusive definition of "response," as set forth in Section 101(25) of CERCLA.

Two response action objectives were established for the Empire Canyon Site:

- Isolation of surface water from mine wastes in the Empire Canyon, consistent with Best Management Practices ; and
- Minimizing the potential for human exposure to elevated lead and arsenic concentrations on recreational trails and potential construction areas.

To address these response action objectives, five response action alternatives were evaluated in terms of Effectiveness, Implementability and Cost, these three groups contain all of the objectives/criteria specified by the National Contingency Plan for non-time critical removal actions. The alternatives are:

- Alternative 1 – No Action
- Alternative 2 – Institutional controls
- Alternative 3 – Waste Isolation, Onsite Repository
- Alternative 4 – Waste Removal, UPCM Property Disposal
- Alternative 5 – Waste Removal, Offsite Disposal

A combination of Waste Isolation with an Onsite Repository (Alternative 3) and Waste Removal United Park City Mines Company property Disposal (Alternative 4) is the recommended response action to protect Site user health and surface water quality. The total cost for implementing this alternative is estimated to be approximately $1,174,752.00. A response action based on the combination of these alternatives provides the best balance between providing the highest degree of environmental protection and cost effectiveness.

1.0 INTRODUCTION

This Engineering Evaluation/Cost Analysis (EE/CA) assesses the proposed action alternatives for the United Park City Mines (UPCM) Empire Canyon Site (Site), an inactive mine and milling area near Park City, Utah (Figure 1). An EE/CA is required under the National Oil and Hazardous Substances Contingency Plan (NCP, 40 CFR 300) for all non-time-critical removal actions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, as amended). A streamlined, focused document, the EE/CA provides site characterization data, assesses health risks, evaluates ecological exposures, evaluates various response alternatives, recommends a preferred response action, and provides a vehicle for public involvement.

In March of 1997, after investigations by the Utah Division of Environmental Response & Remediation (DERR), the Empire Canyon Site was placed on the Comprehensive Environmental Response Compensation and Liability Information System (CERCLIS) list. CERCLIS contains data on potentially hazardous waste sites, which are in the screening and assessment phase for possible inclusion on the National Priorities List (NPL). Environmental investigations in Empire Canyon have reported elevated concentrations of zinc and cadmium in surface water and lead and arsenic in soils. A human health risk assessment has not been included as part of this EE/CA. Ecological exposures have been accounted for in the removal action. Empire canyon is an ephemeral tributary to Silver Creek, which flows into the Weber River sixteen (16) miles north of Park City. The Weber River flows into the Great Salt Lake.

There have been three (3) previous investigations of mine wastes conducted in Empire Canyon over the past several years. In 1999, The Upper Silver Creek Watershed Stakeholders Group (USCWSG) was formed to evaluate hazardous substance impacts to the Silver Creek Watershed. In 2000 a water and sediment sampling program was undertaken by the group. Water sampling occurred in the spring to characterize runoff water in the watershed and in the fall to characterize low flows and sediment chemistry. Using data from 2000 the group determined that the Empire Canyon drainage was a potentially major source of zinc loading to Silver Creek. In 1998 the Utah Division of Water Quality (DWQ) placed Silver Creek on the 303(d) list. The 303(d) listing means that water quality in the drainage does not meet state water quality standards established for that water body. The 303(d) listing is for zinc and cadmium water quality standards. The DWQ has initiated the Total Maximum Daily Load (TMDL) analysis as required in the Clean Water Act and expects to complete the TMDL analysis in 2003. In the spring and fall of 2001 DERR conducted an Expanded Site Investigation. In the fall of 2001 RMC collected soil samples along recreational trails located in the Site. In addition UPCM has collected soil and water samples at various locations from 1999 through 2002. The previously described sampling events are detailed in a Site Characterization Report included in this EE/CA (Appendix A).

1.1 Non Time-Critical Removal Actions

The U.S. Environmental Protection Agency (EPA) has categorized three types of response actions: emergency, time-critical, and non-time critical based on the type of situation, the urgency and threat of release or potential release, and the subsequent time frame in which the action must be initiated. Emergency and time-critical response actions must be initiated within six months; non-time-critical response actions may take more than six months to be initiated.

EPA has determined that a non-time-critical response action is appropriate for the Empire Canyon Site (USEPA, 2002). Non-time-critical response actions require the following process:

- Site characterization (preliminary assessments and site investigations). This process has been completed at Empire Canyon additional sampling may be required to guide remediation;
- Characterization of the release and its associated risks, and the evaluation and recommendation of the appropriate response action in the EE/CA document;
- Development of a formal Community Relations Plan (prepared by EPA with assistance from United Park);
- Establishment of a local public information repository;
- Public notice and a public comment period on the selected alternative;
- Written response to significant public comments;

- Selection of the appropriate response summarized in an Action Memorandum prepared by EPA.

1.2 Report Organization

This EE/CA contains a summary of the environmental characterization and evaluation of human risks and ecological exposures in Empire Canyon. This data is then used as a basis for evaluating response action alternatives and recommending a preferred response action. The presentation of data and the evaluations in this EE/CA are organized into separate sections, as follows:

Section	Topic
Section 1	Introduction
Section 2	Site Description
Section 3	Previous Investigations
Section 4	Site Characterization
Section 5	Nature and Extent of Contamination
Section 6	Risk Evaluation
Section 7	Applicable or Relevant and Appropriate Requirements (ARARs)
Section 8	Response Action Objectives, Schedule and Community Involvement
Section 9	Evaluation of Response Action Alternatives
Section 10	Comparative Evaluation and Cost Analysis
Section 11	Recommended Response Action Alternative
Section 12	References

2.0 SITE DESCRIPTION

The Empire Canyon Site is a historic ore mining and processing area located near Park City, Summit County, Utah. Empire Canyon is located south of Park City (Figure 1). Surface water flow from Empire Canyon occurs in a small ephemeral channel (DERR, 2001). The Site is situated on the eastern slope of the Wasatch Range, approximately 25 miles east of Salt Lake City. Park City rests at the downstream end of Empire Canyon.

The geographic coordinates for the Site are 40° 38'40" north latitude and 111 degrees 29' 38.5" west longitude (Thiros, 2000). To reach the Site, travel south on Main Street in Park City. Proceed past the houses until the paved road changes to gravel, this is the beginning of the canyon. There were several mines, a concentrator, assay office, trams and other mine workings in the canyon up to the drainage divide (Figure 1).

The immediate area around the Site consists of steep canyon walls with mine/mill wastes and mine overburden present in several locations, which slope directly into the Empire Canyon drainage. The terraces or flat spots in the canyon are the locations of former mining facilities and a municipal drinking water tank.

Waste rock piles from the mine operations are located along the canyon walls as well as in the Empire channel. Several worn trails parallel the channel and traverse the mill and mine sites. The canyon is a popular area for residents and visitors to hike and mountain bike. The Empire Canyon drainage originates approximately one mile to the south near the Summit/Wasatch County line.

2.1 Surrounding Land Use and Site Access

Current Site land use activities are primarily limited to dispersed recreational activities that vary with the season. Spring, summer and fall use of the Site is primarily composed of hiking and bicycling. Winter use of the Site includes downhill and cross-country skiing, snowshoeing and snowmobiling. Portions of Park City and Deer Valley ski resorts are located in Empire Canyon.

The Site is easily accessible, as no fences or signs are present to limit access to the Site. The canyon is gated to restrict vehicle traffic. Hiking and mountain bike riding are activities, which are allowed as a regular practice, however these activities are generally confined to designated trails. Much of the area is part of ski resort development, which allows skiers access during the winter months. During that time the Site is effectively capped with several feet of snow.

The topographic layout of the Park City mining district lies between the precipitous cliffs and ledges that mark the main crest of the range and the verdant mountain meadows of Heber City, Kamas, and Parley's Canyon that lie along its eastern foothills. Park City is near the Weber River/Provo River divide, which is the most prominent spur on the east slope of the central Wasatch. This divide is also the boundary between Summit and Wasatch countries. Park City itself sits on the divide between East Canyon Creek and Silver Creek, both of which are tributaries to the Weber River. Empire Canyon is a tributary to Silver Creek. Mountains bound Empire Canyon on the west, east and south, and the Park City residential area on the north.

2.2 Historical and Archaeological Features

Historical and archaeological features of Empire Canyon are primarily related to past mining and ore-processing activities. Major historical mining related sites in Empire Canyon include the Anchor/Judge mine waste rock dump at the location of the Judge Mine shaft, the Daly Mine site, Little Bell and New Quincy mine sites, the Daly West Mine Dump, the Judge Tunnel portal and the Judge/Alliance dump site. In addition to the sites located in Empire Canyon, this evaluation includes sites located in Walker Webster Gulch which drain into Empire Canyon in the vicinity of the Judge Tunnel and the Judge/Alliance dump site.

Minor historical features in Empire Canyon and Walker Webster Gulch include numerous discovery pits and other mine exploration related features. Many of these features are minor exploration features such as discovery pits that were excavated by hand in search of mineralized rock lying directly below surface soils. These features are commonly over one-hundred years old and are typically obstructed by vegetation.

3.0 PREVIOUS INVESTIGATIONS

This section summarizes previous site characterization studies conducted in Empire Canyon. A Site Characterization Report provides all data pertaining to the Site is included in Appendix A. The Site Characterization Report contains maps detailing sample locations. Previous investigations have focused on impaired surface water quality occurring during the spring snowmelt season and potential human health risks associated with historic mine wastes located in the Site area.

3.1 Upper Silver Creek Watershed Sampling Results Spring and Fall, 2000

As part of the USCWSG group, UPCM conducted water and sediment sampling in the spring and fall of 2000 in the Silver Creek watershed including Empire Canyon. Surface water samples were collected in the lower reaches of the drainage in May and June and in the upper reaches in June of 2000. Due to the ephemeral nature of the flow regime, surface water ceased to flow in early June near the Judge Tunnel. Sediment samples were collected in Empire Canyon during September of 2000, water does not flow in the canyon during mid to late summer and fall. Water flow was measured by flow meter and/or bucket and stopwatch, water quality data were collected at nine locations. The sampling program was initiated to collect data of sufficient quality and quantity to identify potential source areas of contaminants that may be adversely impacting water quality in Silver Creek.

Data from the spring 2000 sampling indicate that total zinc concentrations at the Site range from 0.045 to 5.3 mg/l and dissolved zinc concentrations range from 0.011 to 5.3 mg/l. Total cadmium concentrations ranged from <0.001 to 0.046 mg/l, dissolved cadmium concentrations ranged from <0.001 to 0.044 mg/l. As stated in Section 1.0 zinc and cadmium are the two metals of greatest of concern in the TMDL process. Other metals concentrations in surface waters (with the exception of selenium which is close to both standard and analytical detection limit for two samples) are below water quality standards for Silver Creek.

Available sediment data collected in 2000 indicate that lead is present at elevated concentrations in the Site area. Lead in the sediments ranges from 9,025 to 17,120 ppm, cadmium in the sediments range from 57 to 60 ppm and zinc in the sediments ranges from 9,838 to 11,680 ppm. Other metals such as arsenic and antimony are present in concentrations that could be considered above background although background has not been established.

Two analytical summary reports were prepared for the USCWSG and were published in July of 2000 and February of 2001. In the first quarter of 2001 the USCWSG evaluated data collected from the watershed and determined that metals loading from the Empire Canyon drainage required further investigation. In the spring of 2001 DERR and UPCM initiated an Expanded Site Investigation (ESI, DERR, 2001).

Analytical result tables and sample location maps are presented in the Site Characterization Report located in Appendix A.

3.2 State of Utah Department of Environmental Quality – Division of Environmental Response and Remediation, Expanded Site Inspection, Empire Canyon

The DERR initiated an Expanded Site Inspection (ESI) in the spring of 2001. The focus of the ESI was to evaluate contamination exposure and migration pathways associated with ground water, surface water, soil exposure, and air, to determine if human or ecological targets may be exposed through these pathways (DERR, 2001). DERR and UPCM personnel conducted the ESI. The field work was initiated as soon as snowmelt in the canyon provided water to the drainage channel.

Approximately twenty-two (22) surface water samples were collected beginning in the lower reaches of the canyon in late April and culminating with samples at the upper reach of the drainage basin in early July. Figures showing the location of the water samples are presented in Appendix A. According to the ESI Workplan (DERR, 2001) total metal samples were collected for the most part, the data are presented in Appendix A. Of the twenty-two (22) surface water samples collected eighteen (18) samples were analyzed for total metals and four samples were analyzed for total and dissolved metal concentrations. Total zinc concentrations ranged from 0.0001 to 8.87 mg/l, dissolved zinc concentrations ranged from 0.582 to 2.35 mg/l in the four samples.

Tracer testing was conducted in the lower reaches of the canyon from the Judge Tunnel Portal area downstream to the Iron Gate area, in Daly Draw and Walker Webster Gulch. The tracer testing was completed to evaluate shallow surface and groundwater mixing and travel time of the tracer media. Results of the tracer test indicate that during the spring runoff a portion of surface water flows seep into underlying alluvium only to resurface downstream at a lower portion of the channel.

As part of the ESI, fifteen (15) sediment samples were collected in the Empire Canyon and related drainages. Appendix A contains the data and maps portraying the analytical results. Zinc concentrations in the sediments ranged from 63.4 to 29,200 ppm, cadmium concentrations ranged from 0.44 to 165 ppm. Soil samples from mine waste piles and other areas of interest were collected as part of the ESI. Lead concentrations in the soils ranged from 27 to 171,000 ppm, the 171,000 ppm sample was collected from a stream channel. Arsenic concentrations in the soils ranged from 10 to 1,170 ppm. Although arsenic and lead concentrations in the sediment are elevated, very little of these and other metals associated with mine wastes are found in the limited surface water flow of the Empire channel.

The Site Characterization Report, located in Appendix A, contains analytical results and maps showing the sample locations.

3.3 Empire Canyon Trail Sampling

In November 2001, soil samples were collected along recreational trails located in Empire Canyon. A total of fifteen (15) samples were collected to assess the concentrations of metals located in recreational use areas. Samples were collected in areas where trails cross the Judge Mine, Daly West and Alliance mine dumps. Samples were also collected in non-impacted areas to assess background conditions. Soil data collected indicate that lead ranges from 229 to 18,540 ppm, and arsenic ranges from 23 to 349 ppm. The lower values of each range were collected in undisturbed areas and likely contain background values therefore the range of results is representative of both background and impacted locations.

Analytical results tables and sample location maps are presented in the Site Characterization Report located in Appendix A.

3.4 Other Investigations

Analytical results from sampling events conducted by RMC and UPCM in 1999 and 2000 are presented in Appendix A. These sample events were conducted as part of the initial assessment and scoping activities at the Site. Soil and surface water samples were collected in various areas in Empire Canyon and Walker Webster Gulch.

4.0 SITE CHARACTERIZATION

This section provides information on Site characteristics including ecological and environmental characteristics and regional geology, hydrogeology and meteorology.

Water flows in Empire Canyon primarily from spring snowmelt and occasionally during large summer thunderstorms. Flow is dependent upon the volume of snow and spring weather conditions. Water typically begins flowing in the lower reaches of the drainage in May and ends in the upper reaches of the drainage in July.

Groundwater in Empire Canyon occurs in shallow thin alluvial deposits and consolidated rocks. The consolidated rock units in the area can be intersected by vast mine workings. Based on the known hydrogeologic characteristics of the bedrock in the area, most of the water in the consolidated bedrock aquifers in the Empire Canyon area travels to mine workings associated with the Ontario No. 2 Drain Tunnel located below the Judge Tunnel. The Judge Tunnel supplies about 15 percent of the drinking water for Park The alluvial groundwater flow discharges to the surface water within the drainage basin.

4.1 Geology

The geology in the Park City area is relatively complex. It lies on the north side of a broad east-west trending uplift, generally considered to be the westward extension of the Uinta arch (Bromfield, 1968). The major structural feature in the area is the Park City anticline that tends to follow the Ontario Ridge (Gill and Lund, 1984). The bedrock underlying the area consists of quartzites, limestones, sandstones, siltones, and shales ranging in age from Pennsylvanian to Jurassic with Tertiary volcanic and intrusive rocks that lie south and east of the anticline mentioned above (Gill and Land, 1984).

Natural soils within Empire Canyon are locally relatively thin. Apparently during Quaternary glaciation, ice reached the mouth of Empire Canyon (Gill and Lund, 1984). Natural soils in the canyon consist of glacial till and alluvium.

4.2 Hydrology

The basic terrain of the area consists of multiple terraces and steep mountain slopes. The terraces are generally sloping towards the Empire channel. In some areas, the channel is located immediately adjacent to the mine waste piles in the canyon bottom. Flows in the channel are ephemeral and typically occur only in the spring and early summer months, and generally last in duration from a few days to several weeks depending on the snow pack. Water may flow down the canyon during extreme summer storm events. Run-off from snowmelt flows directly into the Empire channel or is absorbed by the soil within the canyon. It is unclear how much run-off water flows through the Site, but the drainage area that contributes to run-off is approximately 1,140 acres which includes Walker and Webster Gulch. The Empire channel is the central channel through the canyon. Water flow from Empire Canyon joins Silver Creek at the Deer Valley confluence about one mile north of the mouth of Empire Canyon.

The surface water flow from Empire Canyon is small relative to other similar mountain watersheds. This small flow is attributed to the loss of surface water to the subsurface because of the thin unconsolidated layer and highly fractured bedrock (Ashland et al., 2001). Subsurface mine workings also likely contribute to these surface-water losses (Brooks et. al., 1998). During the ESI the flow in the Empire channel, at the Iron Gate flume located in lower Empire Canyon, ranges from no flow to an observed high of 5.65 cubic feet per second (cfs). Most of this flow measured during the ESI was made up of Judge Tunnel turn-out water from the Park City Municipal Water System at the Empire Canyon Tank.

4.3 Hydrogeology

Groundwater at the Site occurs in unconsolidated valley fill and consolidated rocks. The unconsolidated valley fill consists of poorly sorted cobbles, gravel, sand, silt, and clay of glacial and alluvial origin. The thickness of the unconsolidated valley fill near the Site varies but is probably relatively thin.

The Permian Weber Quartzite contained vast amounts of water that created major problems for mining operations (Weston, 1997; Gill and Lund, 1984). Most of the tunnels in the area were driven to remove this water from mine workings (Weston, 1997). Fractures in this unit encountered by Judge Tunnel workings at the most distant reaches, still supplies most of the water flowing from the Judge Tunnel. The vast mine workings in the area create a complex preferential flow pathway for subsurface flows in the bedrock (Gee, 2001).

It is suspected that shallow groundwater flows in the same general path as surface water in the Empire Canyon area. Therefore, shallow groundwater flows towards the Empire channel and then as surface water towards Silver Creek in a northerly direction through the Park City area. It is also suspected that shallow groundwater in the canyon locally flows several feet below the surface in the alluvial fill in the bottom of the canyon (DERR, 2001). Due to the fractured nature of the bedrock and other local geologic factors, communication between the shallow alluvial groundwater and the fractured bedrock aquifers is likely in certain areas (Gee, 2001).

4.4 Surface Water

A significant amount of surface water sampling has been conducted at this Site. Sampling results are summarized in Section 3.0 and fully presented in Appendix A.

Along with weather conditions, the flow regime in Empire Canyon is dependent upon the melting rate and the size of the snow pack. Generally the lower reach of the drainage begins flowing in late April to early May with flow in the upper reaches of the drainage ending in July. The flow regime and timing are all dependent upon the snow pack and weather conditions. As the melting snow recedes up the drainage so does the flow; in other words channel flow in the canyon will follow the melting snow. There is currently one Parshall flume in Empire Canyon and one (1) each in the Daly Draw and Walker Webster Gulch tributaries to Empire Canyon. These flumes range in throat size from 6 to 12-inches and allow accurate measurement of flow. Previous sampling efforts by the USCWSG group and DERR have collected flow and water quality samples at these locations (see Figure 2, in Appendix A). Data from these events were previously discussed in Section 3.0. A flume positioned in the channel at a point about 300 feet upstream of the Judge Tunnel was removed for construction reasons in the Summer of 2001. It has not yet been reinstalled. It is likely that this flume will be placed into the channel at the end of the construction season in 2003.

The Judge Tunnel is a source of approximately 15 percent of the drinking water supply for Park City. Groundwater from the tunnel is captured in a pipe at the portal, approximately 100 feet from the outside of the tunnel snow shed and is discharged into a one-million gallon storage tank after it is treated with chlorine to meet public drinking water disinfection standards. In addition, turbidity is measured as the flow enters the tank, if turbidity levels exceed 1 NTU, the flow is automatically turned out of the pipe and into the Empire channel. During mid spring and early summer, flow from the tunnel increases coincident with the melting snow in the canyon. During the spring of the year demand on the public drinking water system is low and excess water from the tunnel overflows from the Empire Canyon Water Tank, part of the municipal drinking water system and discharged into the drainage. Turbidity turnouts occasionally occur in the spring as well and are likely the result of increased water flow in the tunnel. Figure 1 shows the location of the tunnel portal and public drinking water storage tank.

4.5 Springs and Seeps

There are several locations where springs and seeps are found that may produce water during the spring and early summer snowmelt season in the Empire Canyon drainage. These locations do not always produce water and flow appears to be dependent on the depth of snow pack and ambient air temperatures during the snowmelt season. Many are directly related to the melting of snow located on coarse mine waste that is contaminated. Once the snow is completely melted, any flow present disappears. Water quality samples have been collected at these seeps and are presented in the Site Characterization Report located in Appendix A. These springs and seeps do not contribute a significant amount of metals loading to the Empire channel, for the most part the spring and seep flows do not reach the Empire channel. Isolating the contaminated material from snowmelt should prevent these features altogether, thus eliminating any associated contamination.

4.6. Meteorology

The climate of the Park City area is temperate highlands with a typical frost-free season from mid-June to early September. The mean annual precipitation is approximately 20.68 inches (Brough et al., 1987). The 24-hour maximum rainfall is 1.90 inches. Winds in Utah are usually light to moderate and typically are below 20 miles per hour. Occasionally, winds associated with storm fronts or severe thunderstorms exceed 60 miles per hour, but winds associated with storm events are normally between 30 to 40 miles per hour (Brough et al., 1987). Snow cover typically occurs from November through April in the lower elevations from late October/early November through May at the upper elevation portion of the Site. Snow depths at the Site can exceed five feet.

5.0 NATURE AND EXTENT OF CONTAMINATION

This section details the nature and extent of contamination at the Site. For the purposes of this EE/CA, enough is known about metals concentrations at the Site and surrounding areas, such as Prospector Square and Richardson Flat, to determine that the metals of concern at the Site are zinc and cadmium in surface waters and lead and arsenic in soils. Previous analysis of metals concentrations in samples of surface water and soils collected at the two mentioned locations and from the Site reveal that lead and arsenic are indicator metals within soils and zinc and cadmium are indicator metals within surface waters in the general area around Park City. Indicator metals for soil and water at the Site can be used to indicate the presence or absence of other potential contaminants (i.e. if concentrations of the indicator metals are below levels of concern, it can be assumed that other metals are also below levels of concern). The elevated levels of metals at the Site are metals derived from mining related wastes. Information presented in Sections 3.0 and 4.0 as well as the Site Characterization Report (Appendix A) is used to provide a detailed and comprehensive synopsis of environmental conditions at the Site. Sample location maps and data tables are presented in the Site Characterization Report located in Appendix A.

5.1 Soil Related Contamination

Contaminant impacts to soils and sediments at the Site are related to past mining activities. Based upon previous investigations at the Site and surrounding areas, lead and arsenic are two metals that have been identified in soils at levels above standard risk based screening concentrations. The bulk of the Site's 1,140 acres has not been impacted by past mining activities. Areas of impacted soils are generally confined to the vicinity of historical mining areas or activities related to mining. Mining and ore processing activities occurred at multiple locations throughout the Site. Major areas of soil contamination primarily occur in areas that have undergone large-scale mining related activities. Examples of this include the Daly West and Alliance mine dumps. Smaller mine related features such as the numerous discovery/exploration pits do not have as much of an impact to Site soils due to their limited size and low metal concentrations. Impacts to channels are confined to areas downgradient from mine waste locations.

Concentrations of metals in soils and sediment are highly variable throughout the Site. This is primarily due to two factors: 1) the variable nature of soils and 2) sampling bias; samples are typically collected in areas suspected of being background and/or impacted. In general high concentrations of metals in soils are limited to those areas at the Site that have been disturbed by mining related activities.

Potential health threats to Site users are generally limited to areas where recreational trails intersect mine wastes. Remedial Objectives will be met by isolating mine wastes from contact with Site users. This is a requirement in the Annexation Agreement between United Park City Mines Company and Park City. The agreement spells out that all mine sites will be covered and revegetated. Potential health threats to Site construction workers caused by exposures exceeding the site specific human health risk based goals will be mitigated by practices outlined in a Health and Safety Plan. The Health and Safety Plan will be in effect during removal activities and will be developed as part of the removal design process.

5.2 Water Related Contamination

Impacts to surface waters at the Site are related to the interaction of water and mining related materials such as mill tailings and waste rock. Based upon previous investigations at the Site and surrounding areas, zinc and cadmium are the two metals that have been identified in the surface water at levels above water quality standards. Due to the ephemeral flow in Empire Canyon metals loading generally occurs primarily during short periods of time during the spring snowmelt cycle which typically begins in late April or early May and generally lasts until late June or early July. High intensity thunderstorms, which typically may occur during the summer months, have the potential to provide additional surface water available for metals loading however the amount of metals loading caused by such limited flow events is not significant.

Results of surface water and sediment sampling indicate that elevated metal concentrations (i.e. Zn and Cd) in both surface water and sediment can be roughly correlated. Channel reaches containing elevated concentrations of metals in sediments may contain surface water with elevated concentrations of metals. However, there are areas within the Site where stream sediments contain low to moderate metal concentrations and surface water flowing through these areas contain elevated metal concentrations. This indicates that elevated metal content in sediments is not the sole driver for metal contamination in the surface water. Subsurface flows that are exposed to higher concentrations of metal in soils for longer periods of time are likely contributing more metal loading to the stream than contaminated sediments in the stream channel.

The Judge Tunnel can make up the entire flow of the lower Empire channel when being discharged into the channel from Park City's water operations. When runoff has ended, and the channel above the turbidity meter discharge from the municipal water system is dry, Judge Tunnel water and water lost to the ground under the segment of stream downstream of the tank is the only water flowing in the lower channel. As reported by the USCWSG (USCWSG, 2001), Judge Tunnel water does not meet surface water quality standards for Silver Creek which are based on aquatic live criteria. Therefore, based on existing data, it can be ascertained that turbidity bypass water from the Judge Tunnel water discharges can cause the lower section of the empire channel to exceed surface water quality standards even in the absence of contact with any mine waste in the channel.

Tracer studies were used to investigate the potential contribution of metal loading from shallow groundwater flow. The State of Utah DERR (Attachment A, DERR 2002, contained in The Site Characterization Report, Appendix A) conducted tracer studies at the following four (4) flume locations: 1) Middle Empire Canyon, 2) Lower Empire Canyon at the Iron Gate, 3) Daly Draw and 4) Walker Webster Gulch. The DERR flow data detailed in Appendix A provides a synopsis of flows during the 2001 spring runoff cycle, a typical runoff season. Flow was recorded at the Middle Empire Canyon Flume from May 9 through May 14. The maximum flow recorded at the Middle Empire Canyon Flume was 0.67 cubic feet per second (cfs) on May 14. Flow was recorded at the Iron Gate Flume (Lower Empire Canyon) from April 20 through May 24. The maximum flow recorded at the Iron Gate Flume was 6.29 cfs on May 18. This flow included water from the Judge Tunnel. Water was still flowing through the flume on May 24, which was the last recorded flow at this location for the ESI. The flow at the Iron Gate Flume can also contain water from the Judge Tunnel turbidity meter turnout located at the Park City Municipal Water Tank or from tank overflow due to low water demand. Flow was recorded at the Daly Draw Flume from April 30 through May 24. The maximum flow recorded at the Daly Draw Flume was 1.74 cubic feet per second (cfs) on May 14. Flow was recorded at the Walker Webster Flume from May 9 through June 7. The maximum flow recorded at the Walker Webster Flume was 2.18 cfs on May 18. Peak flows occurred at all locations during the time period of May 14 through May 18. Based on the data collected during the spring 2001 runoff cycle, the duration of flow in the main Empire channel lasted approximately one month from April 30 through May 24. The data presented above summarizes a typical spring runoff cycle in Empire Canyon and exemplifies the short duration of the annual runoff cycle. The short duration of the runoff cycle will limit the metal loading to downstream locations.

Based on the results of Site sampling from 1999 through 2002 elevated zinc concentrations appear to be related to the contact and interaction of surface and near-surface waters with mine wastes. For example, as part of the Empire Day Lodge infrastructure construction near the Daly West mine, storm drain culverts were installed upstream of a large section of the Daly West mine waste rock pile. This was done following the ESI study in 2001. This storm drain system collects surface drainage coming down from the upper Empire Canyon area and from the Empire Lodge area and carries it to the channel at the downgradient toe of the Daly West pile. Samples collected directly below the Daly West mine dump in 1999, 2001, and 2002 indicate a reduction in the concentrations of zinc over this time period in the water emanating from the mine dump area. In 1999 total and dissolved zinc concentrations in sample Emp-Daly-WF were 3.7 and 3.4 ppm, respectively (*See*, Figure 3 and Table 8 in the Site Characterization Report Appendix A). Prior to installation of the culverts and during the ESI study total zinc concentrations were 5.1 ppm (*See*, Figure 3 and Table 3 in the Site Characterization Report Appendix A), dissolved metals were not measured at most locations during the ESI study. Generally, at this Site the dissolved fraction makes up approximately 90% of the total metal concentration. In the spring of 2002, sample EC-SW-06 was collected from the discharge culvert installed through the mine dump. The sample contained total and dissolved zinc concentrations of 0.88 and 0.019 ppm respectively. (*See*, Figure 4 and Table 9 in the Site Characterization Report, Appendix A). This data indicates that Remedial Objectives can be met by isolating surface from contaminated mine wastes.

Elevated concentrations of zinc observed in the reach below the Daly West mine dump and adjacent to the old Daly No. 1 Mine Shaft area (samples ECA-SW-11 and ECA-SW-10) are most likely attributed to slight discharges of groundwater observed in this location. The source of the groundwater may be snowmelt waters seeping into the ground above the Daly West area and then emanating as surface water or quite possibly water resurfacing after it enters the ground in the small drainage to the north and east of the Daly West mine pile. This water entering the ground was observed during the May 2000 USCWG sampling event As mentioned above, The high concentrations of zinc in the samples mentioned above may be the result of this groundwater discharge. If this groundwater discharge is connected to the surface water flowing down the draw north and east of the Daly West mine then zinc concentrations increase around 50 times as it moves through the ground in this area and then flows out on to the surface of the ground. Some of the culverts installed in 2001 captures some of the flow at the head of this drainage. Restoration of the stream channel using clean fill and an impermeable clay liner to keep the water on the surface of the ground should greatly enhance water quality in this area.

In the summer of 2002, additional culverts and surface ditches were installed upstream of and adjacent to a large portion of the Daly West mine dump. This was done as a continuation of the development of the Empire Day Lodge area and as part of the Flagstaff Mountain Resort. A portion of the dump was covered with clay fill. All of this work was done as part of the Flagstaff Development Project and also went towards the primary objective of removing contaminated material from surface waters. As a result, sampling in 2003 may show a further reduction in zinc concentrations at these downstream locations between the Daly West mine dump and the Judge Tunnel.

As a by-product of the 2002 Flagstaff infrastructure construction activities near the Site, a possible reduction in the amount of mine by-products available for interaction with surface waters has been obtained. As mentioned above, the Daly West surface drainage system will continue to be improved resulting in less upstream water coming into contact with the waste rock pile. The waste rock pile is being recontoured and portions of the pile were capped with fill in the fall of 2002. This should help decrease the amount of any surface water infiltration into the dump. The remainder of the Daly West mine dump will be capped in 2003 as part of this response action.

The lower section of the canyon, defined as from the Judge Tunnel downstream to the sediment pond, located about 1500 feet north of the Iron Gate, contains tailings and some mine rock in direct contact with the runoff waters. Water quality is directly affected by the mine wastes located in the stream channel in this segment of the drainage. The confluence area of the Walker-Webster Gulch with Empire Canyon also contains tailings in direct contact with surface waters.

Surface water samples collected in the previously remediated reach of Walker-Webster Gulch located directly below the Keystone Mine (*See*, Figure 1) contain slightly elevated concentrations of zinc. Dissolved zinc concentrations range from 0.046 to 0.76 ppm. Tracer testing (Attachment A, DERR, 2002) indicated a connection between the water in this reach and a dye injection point located above the Keystone Mine. Additionally, the tracer testing performed in the vicinity of the Keystone Mine indicates that a set of seeps unrelated to the Keystone Mine located above and to the east of the remediated section (*See* Figure 1, Tracer

Study, Appendix A) do not have a hydrologic connection to flow in the channel other than their direct surface contribution to that flow. A sample collected from these seeps in 2002 contained a dissolved zinc concentration of 0.074 ppm.

From field observations, the lower section of Walker Webster Gulch, which lies below the remediated reach and above the flume located at the bottom end of Walker Webster Gulch, is a losing section of the channel. This losing reach provides a pathway for surface water to enter the ground and interact with mine waste rock located in the mine dump at the portal of the Alliance Tunnel. The tracer study indicated that at least a portion of the water lost in the section below the flume flows underground until it resurfaces in the Empire channel. Based on the results of DERR sampling, the interaction of the water and the mine waste rock below the Walker/Webster flume appears to increase the zinc concentrations in the surface water below the confluence of Walker Webster gulch and Empire Canyon (DERR, 2002).

The tracer study data indicate the reach of Daly Draw above the flume is losing water. The testing indicates that the water flows underground and then resurfaces and mixes with water in the Empire channel. The water flows through an area of mine waste prior to its interception by the Empire channel. Isolating this water in Daly Draw and keeping it flowing on the surface would significantly reduce the water/mine waste interaction and hence the zinc loading.

During the 2002 sampling efforts, the PCMC water tank overflow was sampled. On May 6, 2002 during the Site Characterization sampling the tank was overflowing into the Empire Channel and water quality samples were collected and submitted for analyses. The data are presented in Table 10 of Appendix A and indicate that cadmium and zinc exceed applicable water quality standards for Silver Creek downstream of Empire Canyon.

In summary, the major source of metals loading in the waters of Empire Canyon is most likely caused by the interaction of surface and near-surface water and mine waste and discharges from the Judge Tunnel. Stream contaminant levels are strongly influenced by discharges of shallow groundwater that was once surface water which has been contaminated by flowing into the shallow groundwater regime and through contaminated mine related materials or contaminated stream sediments. Based on the data presented in this EE/CA it appears that when surface water goes into contaminated alluvium and reappears downstream it contains increased concentrations of zinc or other metals. Areas that have undergone remedial activities to isolate surface water from contact with mine waste, such as the Daly West mine area, have seen a significant reduction in metal contribution to surface water. The isolation of surface waters from mine waste throughout the Site will reduce the amount of metals loading in surface waters in the Empire Canyon drainage. Utilizing culverts and lined channels and the diversion of surface waters via capping will reduce the amount of surface water percolation into mine waste. This will reduce the amount of water available to interact with mine waste and hence, will lower the concentrations of metals in surface waters.

6.0 RISK EVALUATION

A qualitative ecological risk evaluation was conducted as part of this EE/CA. This section provides a summary of the evaluation.

6.1 Ecological Assessment

A qualitative assessment was conducted to evaluate ecological pathways at the Site. The purpose of the qualitative assessment is to identify potential ecological receptors and evaluate the reduction in exposure resulting from the response action proposed by the EE/CA.

6.1.1 Sources and Ecological Metals of Concern

As previously described in Sections 3, 4 and 5 the source of contamination at the Site are wastes derived from previous mining activities. The metals of concern at the Site are metals derived from mining related waste. Some metals identified in the analysis associated with this EE/CA have the potential to be indicator metals for terrestrial receptors. Lead, arsenic, cadmium, and zinc are likely terrestrial indicator metals at the Site. Zinc and cadmium have been identified as aquatic indicator metals in the Silver Creek TMDL process. Empire Canyon is an ephemeral tributary to Silver Creek and during the spring runoff over a time period ranging from weeks to less than three months, depending on the available snowpack to generate the runoff, the canyon does provide metal loading to Silver Creek. Due to the ephemeral hydrologic regime there are likely no aquatic receptors present in Empire Canyon.

6.1.2 Exposure to Terrestrial Receptors

The terrestrial receptor exposure at the Site is limited to and focused on wildlife receptors. Ecological exposure to plant fauna have not been examined at the Site. Site wildlife use was based on a study performed for the Flagstaff Mountain Resort by SWCA, Inc. Environmental Consultants (SWCA, 2001). The Flagstaff Mountain Resort is located in Empire Canyon but contains properties that are excluded from the Empire Canyon EE/CA process (*See*, Empire Canyon AOC, USEPA, 2002).

Exposure media for terrestrial receptors includes mine wastes, sediment, prey (food chain) and surface waters. Exposure pathways include direct ingestion and uptake through the food chain.

Ground cover and wildlife habitats at the Site include conifer, conifer/aspen, aspen/tall forb, mountain shrub and native/seeded herbaceous types of cover/habitat (SWCA, 2001). Non-vegetated areas at the Site include rock outcrops; talus slopes and mine dumps (mine dumps comprise approximately 3.2 percent of the Site area).

Typical large mammals that occur or may occur at the Site include: moose, elk, mule deer, coyote, bobcat and mountain lion. Common small mammals include yellow-bellied marmot, porcupine, southern red-backed vole, snowshoe hare, pica, northern pocket gopher, red squirrel, least chipmunk and golden mantled ground squirrel. Bird species in the area include Clark's nutcracker, Steller's jay, northern flicker, mountain chickadee and redbreasted nuthatch (SWCA, 2001).

In general terrestrial exposures are limited to areas where contamination is present, that is, areas that have been impacted by past mining activities. These areas include mine dumps, waste rock piles and portions of ephemeral channels located downgradient from large mine features. Small exploration related features located throughout the Site pose minor exposure due to the limited spatial distribution, lack of high-grade mineralization and lack of mineral processing resulting in low concentrations of metals at these exploration sites. The contribution to the overall exposure at the Site from these features is likely to be insignificant.

The spatial distribution of the historical mine waste features is limited to 3.2 percent of the Site. Figure 1 shows the mine waste areas both remediated and non-remediated within the Site area, there are approximately 1,142 acres in the study area as compared to 36 acres of non-remediated mine wastes. Exposure to metals in the soils on the remainder of the Site is likely minimal. It is unlikely that terrestrial receptors would use the mine waste sites for more than a transit route from one area to the next. The mine waste sites offer very little in the form of habitat as compared to the surrounding area.

Exposed mine wastes pose the greatest exposure for terrestrial receptors on the Site. Over the past several years United Park has been remediating most of the significant mine features in the Empire Canyon drainage basin. Portions of the Judge, Daly West and Little Bell mine dumps have been remediated, the Keystone Mine dump has been completely remediated. Tailings have been removed from the upper section of Walker Webster Gulch. The steep, unvegetated slopes of the mine dumps do not contain suitable habitat for many of the species listed above. In general, a large amount of high quality habitat is located throughout the Site and is undisturbed by mining activities and therefore terrestrial receptors are more likely to inhabit these more desirable locations.

Remedial activities outlined in this EE/CA will further reduce exposure to terrestrial receptors by covering dumps and removing mine waste from channels. The Daly West mine dump will be recontoured to minimize infiltration, covered with clean soil and revegetated with native and non-native grasses, forbs and shrubs. This will reduce the exposure of metal contaminants to ecological receptors. There will be some steep dump faces that will not be remediated due to the adverse slopes they contain, these areas do not contain suitable habitat and hence receive only limited use by ecological receptors. The northern end of the Alliance dump is too steep to reclaim, however, the south and middle section will be covered with clean fill, and revegetated. The removal of mine waste from channels will reduce the exposure to receptors that may use the channel as a water source during the limited snowmelt cycle.

6.1.2.1 Threatened and Endangered Species

Two federally listed threatened and endangered species have the potential to occur within the Site (SWCA, 2001).

The bald eagle is federally listed as a threatened species. Bald eagles typically construct nests in the vicinity of water bodies that support fish populations. Due to the lack of habitat bald eagles are likely to occur within the Site only on a transitory basis during migration (SWCA, 2001).

The Canada lynx is listed as endangered. In theory there may be some suitable lynx habitat in the vicinity of the Site. However, the lynx typically requires large contiguous stands of mature forest, which do not occur at the Site. Furthermore, the lack of any documented lynx sightings in Utah for over seventeen years suggests that this species has been extirpated from the area (SWCA, 2001).

6.1.3 Exposure to Aquatic Receptors

Exposures to aquatic receptors at the Site are limited by the ephemeral characteristics of the Empire channel and its tributaries. As discussed in Section 4.0 the flow in the Empire channel is generally limited to the spring snowmelt runoff season which typically occurs from late May through early June depending on snow-pack and melting conditions. The channels occasionally flow during large summer storm events, however the contribution of this type of flow to the overall total flow of Silver Creek is insignificant.

Due to the shortness of the flow season, typically ranging from several weeks to less than two months in the Empire channel, aquatic organisms are likely not present. If aquatic organisms are present they would likely be transitory in nature and population densities would likely not be very large. However the Empire Channel is a tributary of Silver Creek which does contain aquatic wildlife. Silver Creek contains year-round flow from multiple sources. Mining related waste is present in Silver Creek and its other tributaries including Empire Canyon. Silver Creek is currently on the State of Utah 303(d) list of impaired surface waters. Silver Creek is on the list because the water routinely exceeds zinc water quality standards and occasionally cadmium standards. Empire Canyon has been identified as a source of metals loading to Silver Creek by the EPA in its analysis of the USCWG data collected in 2000.

Removal of mine wastes in the channel and covering the majority of the mine dumps in Empire Canyon will reduce metal loading to Silver Creek during those times when water flows from Empire Canyon. This potentially may result in a reduction of metal availability to aquatic receptors in the upper reaches of Silver Creek. As previously mentioned, minimizing contact of surface waters with mine wastes has been demonstrated at the Site to effectively reduce zinc concentrations in the Site surface waters. There has been a 78 percent reduction in zinc concentrations in surface water at the toe of the Daly West mine dump by installing culverts in and around the dump.

Remedial activities outlined in this EE\CA will reduce metals loading to Silver Creek by reducing the contribution of the Empire Canyon component. This decrease in loading will reduce exposure to metals for downstream aquatic receptors in proportion to the degree that Empire Canyon contributes to the total loading of the Silver Creek Ecosystem.

6.1.4 Ecological Exposure Summary

Based on the information presented in Sections 6.1.1 through 6.1.3, the exposures to heavy metals for ecological receptors at the Site is limited to where mine wastes are present and is likely insignificant for the remainder of the Site area. As stated in Section 6.1.2, the quality of habitat on the mine wastes piles is poor and it is likely that these areas would only be used in a transitory fashion and therefore the mine waste areas would not be a significant contributing factor to terrestrial receptors. In addition, as mentioned in Section 6.1.2 the non-remediated mine waste areas only represent 3.2 percent of the total Site area and this percentage will be further reduced after removal activities outlined in this document are conducted.

Water quality in Empire Canyon and possibly upper Silver Creek will likely be improved by removal activities planned in the EE/CA. Site specific data demonstrate that isolating mine wastes from contact with surface water can significantly reduce zinc concentrations in the surface water.

6.2 Human Health Risk Assessment

A human health risk assessment is not included in this EECA. United Park has a commitment with Park City Municipal Corporation to cover mine waste dumps and recreational trails as part of the Flagstaff Mountain Resort development agreement. Preliminary Remediation Goals (PRG's) developed in the risk assessment indicate that there is little risk to site workers and visitors in the current condition of the site. However, United Park is committed to the development agreement and will cover the mine dump surfaces and recreational trails. In addition, United Park may re-route trails to avoid mine wastes where appropriate.

The primary factors driving human health based remedial activities at the Site are based on the Development Agreement with Park City, land stewardship, public safety and maintaining a positive relationship with the local community.

Potential exposure pathways at this Site are being addressed by isolation and/or removal of mine wastes from exposure areas. Because of the nature of this Site, including steep terrain and snow cover for approximately 6 months each year, potential human exposures are limited. Land use on the site is limited to recreational use and therefore potential exposures to mine wastes would occur only during the 6-month period without snow cover. There may be potential exposures to construction workers either conducting the removal activities or installing infrastructure in the canyon to support the Flagstaff Mountain Resort development. Removal work proposed within this EE/CA will be conducted under a site specific health and safety plan designed to reduce exposure potential to site workers.

Potential human exposure pathways to mine wastes will be mitigated by covering mine wastes on recreational trails and mine dumps. Most recreational visitors to the Site hike or bike on existing trails, as part of the preferred remedy those trails will either be re-routed or covered with clean fill to mitigate the potential exposure to lead and arsenic. Areas not covered with clean fill include the steep faces of mine dumps which contain slope angles which are adverse to covering (i.e. slope faces which are at or steeper than the angle of repose of the emplaced clean fill) or recreational use (i.e. they are not used). Due to their steepness, these dump faces are not used by recreationalists and hence, are not a potential exposure pathway. Minor isolated mine features that do not receive significant human visitation (i.e. are not accessed by commonly used trails and/or roads) may not be covered, these features will be evaluated on an individual basis.

7.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

This section presents a summary of applicable or relevant and applicable requirements (ARARs) for the Empire Canyon Site. The National Contingency Plan (NCP) requires that fund-financed removal actions under CERCLA Section 104 and removal actions pursuant to CERCLA Section 106 attain applicable or relevant and appropriate requirements (ARARs) under federal environmental or state environmental or siting laws "to the extent practicable" considering the urgency of the situation and the scope of the removal action (See 40 C.F.R. Part 300.415(j)). The detailed analysis of removal action alternatives will summarize which requirements are applicable or relevant and appropriate to an alternative and will describe whether and how the alternative will meet the requirements (See Section 8.0, below).

7.1 Contaminant-Specific, Location-Specific and Action Specific Requirements

ARARs are divided into contaminant-specific, location-specific and action-specific requirements.

Contaminant-specific ARARs govern the release of material containing specific contaminants. In the case of the Empire Canyon Site these contaminants are metals.

Location specific ARARs relate to the geographic or physical location of the Site, rather than the nature of contaminants. These ARARs place restrictions, such as the concentration of hazardous substances or the conduct of cleanup activities, due to their location in the environment.

Action-specific ARARs are usually technology or activity based requirements on actions taken with respect to hazardous substances. A particular remedial activity will trigger an action specific ARAR. Unlike chemical or location specific ARARs, action specific ARARs do not determine the remedial alternative to be used, but rather how the selected remedy must be achieved.

The remedial alternatives presented in this EE/CA were selected based on a combination of contaminant-specific, location-specific and action-specific ARARs.

7.2 Definitions of "Applicable" and "Relevant and Appropriate"

Applicable

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by the state in a timely manner and are more stringent than Federal requirements may be applicable.

Relevant and Appropriate

Relevant and appropriate requirements means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site. Only those State standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate.

7.3 Summary of Potential ARARs for Empire Canyon

A detailed list of ARARs applicable to the Empire Canyon Site are summarized in Table 1. These ARARs were developed to encompass all relevant to activities conducted onsite.

8.0 RESPONSE ACTION OBJECTIVES, SCHEDULE AND COMMUNITY INVOLVEMENT

This section details response objectives, the anticipated project schedule and information community involvement.

8.1 Response Action Objectives

Response action objectives (RAOs) were developed based on the nature and extent of contamination as documented in current and previous studies (Section 3.0), the development agreement between United Park and Park City Municipal Corporation, and the potential ARARs.

Two sources of contamination have been identified in the EE/CA, they are:

- Metals in soils, mine waste rock, sediments; and
- Metals in surface waters.

Two RAOs have been established for the Site:

1. Isolation of surface water from mine wastes in the Empire Canyon Site, consistent with Best Management Practices (BMPs); and
2. Minimizing the potential for human exposure to elevated lead and arsenic concentrations on recreational trails.

Best Management Practices, or BMPs, are a combination of management, cultural, and structural strategies that are the most effective and economical way of controlling problems without adversely impacting the quality of the environment. For example, United Park will use BMP's such as compliance with stormwater permits, moving biking trails away from construction areas, installing check dams for stormwater control and dust suppression during construction activities to meet the RAO's specified in this EE/CA.

The selection of the response action objectives are discussed below.

8.1.1 Metals in Soils

Site characterization activities indicated that elevated concentrations of lead and arsenic are present in mine wastes and soils at the Site. To achieve the RAOs United Park will cover mine dump surfaces and recreational trails, and in appropriate areas either close trails or reroute them away from contaminated soils.

Methods to meet RAOs at the Site will include placing clean, low permeability soils on areas where recreational users are likely to come into contact with elevated concentrations of lead and arsenic. In addition some trails will be re-routed. The surface of mine dumps will be covered with clean fill and revegetated reducing potential exposure to site visitors. Covering the slopes of mine dumps will be dependent upon the slope angle of the particular mine dump, for example most if not all of the Daly West Mine dump will be covered, whereas the Alliance Mine dump near the Judge Tunnel will have the surface covered but not the outslope as it is too steep to hold the fill material. Site workers will be protected by a Site-specific health and safety measures plan.

8.1.2 Metals in Surface Waters

Previous Site characterization activities have identified the presence of elevated zinc and cadmium in surface waters at the Site.

The source of metals in surface waters at the Site is mine waste. Surface water becomes impacted as it flows through and comes in contact with mine wastes. To achieve the RAO's United Park will conduct a combination of activities including removal of mine wastes from stream channels, installing culverts in key locations, capturing and conveying stormwater around mine dumps.

Tailings will be excavated, where present, in the Empire channel from the Judge Tunnel downstream to the sediment pond at the mouth of the canyon. The channel will be reconstructed using low permeability clay materials and riprap where appropriate. Tailings will be removed from the lower section of Walker & Webster Gulch. In tributary channels spring runoff flows percolate into the ground only to resurface downstream in the Empire channel. These flows will be kept on the surface either by reconstructing the channels will low permeability materials or if needed pumping grout into void spaces in the channel materials. Other methods to isolate mine waste from contact with surface water will include but will not be limited to: Diverting water away from impacted areas using a series of stormwater diversion ditches, covering mine dumps with low permeability soils, capturing channel flow prior to loss in losing sections of channel and reconstructing losing sections of channels to maintain surface flows. Culverts may also be used in areas where water flows through mine waste areas. In general, surface water RAOs will be met by isolating surface and near surface water from impacted mine waste.

8.2 Response Action Schedule

UPCM and EPA have signed an Administrative Order on Consent (AOC) to conduct the EE/CA on May 14, 2002. The following time schedule is anticipated to complete the EE/CA process:

Task	Proposed Schedule
Draft EE/CA Submittal	March 3, 2003
Establish public information repository	July 16, 2003
Distribute fact sheet	August 19, 2003
Community meeting	August 19, 2003
30-day public comment period	Starts July 19, 2003
Action memorandom Signed	August 21, 2003
AOC Signiture	August 21, 2003

UPCM will support EPA on relevant tasks associated with community relations.

8.3 Community Involvement

Consistent with the requirements of the NCP, the EPA will prepare a Community Relations Plan. However, for this site the EPA has previously prepared a Community Relations Plan for the USCWSG and will prepare an addendum to this plan for the Empire Canyon Site. UPCM will support EPA on relevant tasks associated with community relations.

Fact Sheet: The EPA will prepare a fact sheet. The fact sheet will provide pertinent facts about the proposed action.

Community Meetings: The EPA will schedule a community meeting. The community meeting will allow the public to inquire about and comment on the proposed action.

Public Notices: A public notice will be published in the Park Record.

Public Repositories: A public repository will be established in the Park City Library.

9.0 EVALUATION OF REMOVAL RESPONSE ACTION ALTERNATIVES

This section presents five (5) removal response action alternatives proposed to achieve the response actions described in Section 7.0. There are several removal response action alternatives that could have been considered for this EE/CA in addition to the five that were selected for evaluation. The other potential alternatives include:

- complete removal of all mine wastes on the site,
- capturing and treating all runoff water in the channels, and
- installing culverts in the channels

These alternatives were not investigated further.

The complete removal of all mine wastes on-site was not investigated further due to it being impractical and extremely expensive to remove all impacted materials from the site. The benefits of removing all of the mine waste would be negated by the disruptive nature of the removals from multiple sites as well as the costs.

Capturing and treating all runoff water in the channels is not feasible due to the flows being ephemeral (only three months out of the year). This response action would not be cost effective or permanent and would require annual upkeep and maintenance as well as dedicated personnel to insure that the facility is functioning correctly. A temporary water treatment plant would require an unknown start-up/shutdown period every year.

Installing culverts in the channels would drastically change the aesthetics of the canyon and the culverts would have to be maintained and would not be permanent. Isolating surface water from the surface would disrupt the natural ecological balance of the canyon.

The proposed response action alternatives include the following:

- Alternative 1 – No Action
- Alternative 2 – Institutional controls
- Alternative 3 – Waste Isolation, Onsite Repository
- Alternative 4 – Waste Removal, UPCM Property Disposal
- Alternative 5 – Waste Removal, Offsite Disposal

Alternatives 3 through 5 contain similar remedial designs, with the difference being attributed to the disposal methodology and location of contaminated material.

9.1 Assumptions

Inherent in the development and the discussion of the proposed alternatives are the following assumptions:

Site Usage: Due to the dispersed nature of contamination at the Site, those portions of the Site not undergoing remediation will remain open to public use during remedial activities at other locations. Areas undergoing removal activities will be closed for the duration of such activities. Trails undergoing removal activities will be closed until remediation is complete or at such time when reopening the trail is in the best interest of the public.

Construction and Infrastructure Installation: Construction activities will take place concurrently with response activities at some locations within the Site. Although development is not planned for the Site, it is anticipated that construction activities to provide infrastructure to neighboring properties will occur.

Any land use restrictions will be related to potential future use, recreational land use restrictions are not currently planned.

9.2 Evaluation Criteria

As specified by EPA guidance (USEPA, 1993), each response alternative is evaluated in terms of three criteria: Effectiveness, Implementability and Cost. These three criteria encompass the elements required to meet NCP removal criteria. The criteria are described below:

Effectiveness: The effectiveness of a proposed alternative refers to the ability to meet the response action objectives, and to the degree of protectiveness of the environment as well as public and site worker health, both in the short and long term. For the Empire Canyon Site the RAOs are:

1. Isolation of surface water from mine wastes in the Empire Canyon Site, consistent with Best Management Practices; and
2. Minimizing the potential for human exposure to elevated lead and arsenic concentrations on recreational trails.

Effectiveness also includes the degree of compliance with ARARs.

Implementability: Implementability addresses the technical and administrative feasibilty of implementing an alternative. Technical feasibilty includes the difficulty of conducting the proposed response action. Administrative feasibilty includes issues such as permitting, availability of services and disposal sites and the likelihood of public and regulatory acceptance.

Cost: The cost of each proposed alternative includes direct and indirect capital costs as well as operations and maintenance (O&M) costs. Estimated costs for each proposed alternative are presented in Tables 2-5.

9.3 Alternative 1 – No Action

Alternative 1, No Action, is a baseline alternative by which other alternatives may be compared. No Action involves not taking any further actions to manage environmental concerns at the Site.

Effectiveness: The Site would remain as is. Implementation of the No Action alternative would not achieve the first RAO.

Implementability: The No Action alternative is technically feasible to implement.

Cost: As this alternative does not involve taking any actions at the Site, there are no associated costs.

9.4 Alternative 2 – Institutional Controls and Site Monitoring

Alternative 2 involves implementing institutional controls to control and warn users of hazards that they may encounter while using the Site. Institutional controls will include a set of written agreements for contractors working in impacted areas and land use deed restrictions. Institutional controls for recreational users will include the posting of warning signs and "No Trespassing" signs and fencing to keep them out of impacted areas. Portions of trails would be closed and/or re-routed. Site construction workers would be trained in proper health and safety protocol as well as construction Best Management Practices (BMPs). A five (5) year monitoring program would be implemented to evaluate that the environmental quality of the Site is meeting the site objectives.

Effectiveness: Implementation of Institutional Controls and Site Monitoring would achieve a portion of the RAOs. The potential for human exposure to metals would be reduced given the assumption that recreational users obeyed posted closures and regulations. Construction worker exposure would be limited by following health and safety protocol. Surface water quality would likely not change as institutional controls and monitoring would not reduce water contact with mine wastes.

Implementability: Institutional Controls and Site Monitoring is technically feasible with no anticipated difficulties. The Site is located on land wholly owned by UPCM, therefore no access agreements are required. Site users would be expected to comply with temporary closures. Some trails through contaminated areas may be rerouted.

Cost: Costs for implementation of Institutional Controls and Site Monitoring are presented in Table 2. The estimated total cost for implementation of Institutional Controls and Site Monitoring is $367,200.00.

9.5 Alternative 3 – Waste Isolation with Onsite Repository

Alternative 3, Waste Isolation with Onsite Repository, involves removing and isolating areas of mine wastes at the Site from the environment. Certain areas in Empire contain mine wastes in the channels that would be excavated. Some segments of the channels will be lined with clay to keep water on the surface. The channels would be reconstructed using clean rip-rap materials and/or culverts in order to maintain the integrity of the clay liner and to control flows where needed. A schematic cross section of a reconstructed channel is provided in Figure 3. Recreational trails containing mine waste will be covered with clean material. Areas of trails may also be rerouted if in the interest of public safety. The Daly West mine dump will be recontoured and covered with clean material. In certain areas surface water flow in the vicinity of the Daly West mine dump will be re-routed to minimize contact with waste rock. A cut-off ditch will be placed on the upgradient side of the dump. Surface water from the Empire, Daly Draw and Walker Webster channels at the confluence area of all three drainages will be directed into underground culverts and isolated from waste rock. Mine waste removed from channels and trails will be placed in an onsite repository. The onsite repository will be constructed using a clay liner on the bottom and then will be covered to isolate the waste from the environment. The onsite repository will be located in the vicinity of the slide area which is located downstream and east of the Judge Tunnel (Figures 2 and 4). A geotechnical evaluation of the repository site was prepared by Applied Geotechnical Consultants, Inc. for DMB Associates in the form of a letter report (AGEC, Appendix B). The AGEC evaluation determined that the proposed repository site is stable and gives geotechnical specifications for filling. Design details for the repository will be provided in a Technical Design Memorandum. The Technical Design Memorandum will be submitted to EPA immediately following approval of the Action Memorandum. Best Management Practices will be employed to assure the longevity of the repository cover. Approximately 4,500 linear feet of channel will be remediated in lower Empire Canyon. Approximately 2,500 feet of recreational trail may be remediated throughout Empire Canyon. In addition, remedial activities will be conducted in areas containing significant amounts of impacted waste rock (e.g. Alliance mine dump and Daly West). These areas will be regraded and covered with clean material to conform to the Flagstaff Mountain Resort Development Agreement. The Site will be monitored for five years to ensure that the remediation is effective in improving the environmental quality of the Site. Institutional controls will be implemented as required for the protection of site workers and recreational users. Best Management Practices will be followed during all remedial activities.

Implementing Waste Isolation with Onsite Repository would comply with ARARs and RAOs.

Effectiveness: Implementation of Alternative 3 is technically feasible. The isolation of mine waste will reduce the environmental exposures of metals onsite to surface water, Site workers and recreational users. The removal of mine waste from the Empire and Walker Webster channels will prevent the leaching of metals into surface water. Capping mine wastes on recreational trails will prevent recreational users from being exposed to metals and comply with ARARs.

Implementability: Alternative 3 is technically feasible to implement with no anticipated technical difficulties. Services required will include a remedial construction contractor familiar with the anticipated environmental conditions. Materials required will include clay liner material, culvert material and clean fill material, all of which are readily available.

Cost: Cost estimates for implementation of Alternative 3 are presented in Table 3. The total estimated cost for implementing Waste Isolation with Onsite Repository implementation is $1,093,554.49.

9.6 Alternative 4 – Waste Removal, UPCM Offsite Property Disposal

Alternative 4, Waste Removal with UPCM Offsite Property Disposal , involves both removal and isolating areas of mine wastes from the environment. Certain areas in Empire Canyon contain mine wastes in the channels that will be excavated. The channels will be reconstructed using clean rip-rap materials and/or culverts. Some segments of the channels will also be lined with a clay liner to keep water on the surface. Recreational trails containing mine waste will be covered with clean material. Areas of trails may also be rerouted. The Daly West mine dump will be recontoured and covered with clean material. In certain areas surface water flow in the vicinity of the Daly West mine dump will be re-routed to minimize contact with waste rock. A cut-off ditch will be placed on the upgradient side of the dump. Surface water from the Empire, Daly Draw and Walker Webster channels will be directed into an underground culvert and isolated from waste rock. Mine waste removed from channels and trails will be transported to Richardson Flat. Richardson Flat is a mine tailings site owned by UPCM. The material is similar to that at Richardson Flat and will be contained within the tailings impoundment, which is currently undergoing a Remedial Investigation and Feasibilty Study. Approximately 4,500 linear feet of channel will be remediated in lower Empire Canyon. Approximately 2,500 feet of recreational trail may be remediated throughout Empire Canyon. In addition, remedial activities will be conducted in areas containing significant amounts of impacted waste rock (e.g. Alliance mine dump and Daly West). These areas will be regraded and capped with clean material. The Site will be monitored for five years to ensure that the remediation is effective in improving the environmental quality of the Site. Institutional controls will be implemented as required for the protection of Site workers and recreational users. Best Management Practices will be followed during all remedial activities.

Implementing Waste Removal with UPCM Offsite Property Disposal would comply with ARARs.

Effectiveness: Implementation of Alternative 4 is technically feasible. The removal of mine waste will reduce the environmental exposures of metals onsite to surface water, Site workers and recreational users. The removal of mine waste from the Empire and Walker Webster channels will prevent the leaching of metals into surface water. The removal of impacted mine wastes from recreational trails will prevent recreational users from being exposed to heavy metals.

Implementability: Alternative 4 is technically feasible to implement with no anticipated technical difficulties. Services required will include a remedial construction contractor familiar with the anticipated environmental conditions at the Site and a transportation company to transport the material to Richardson Flat which is located approximately six miles away. Over 700 truck loads of materials will have to be transported through the heavily congested town of Park City. This off site transportation may cause some adverse public opinion and potentially put the public at risk due to increased traffic and material spillage. Materials required will include clay liner material, culvert material and clean fill material, all of which are readily available.

Cost: Cost estimates for implementation of Alternative 4 are presented in Table 4. The total estimated cost for implementing Waste Removal with UPCM Offsite Property Disposal implementation is $1,354,171.63.

9.7 Alternative 5 – Waste Removal, Offsite Treatment and Disposal

Alternative 5, Waste Removal with Offsite Treatment and Disposal, involves removing and isolating areas of mine waste from the environment. Certain areas in Empire Canyon, containing mine wastes in the channels, will be excavated. The channels will be reconstructed using clean rip-rap material and/or culverts. Some segments of the channels will also be lined with clay to keep water on the surface. Recreational trails containing mine waste will be covered with clean material. Areas of trails may also be rerouted. The Daly West mine dump will be recontoured and covered with clean material. Surface water flow in the vicinity of the Daly West mine dump will be re-routed to minimize contact with waste rock. A cut-off ditch will be placed on the upgradient side of the dump. Surface water from the Empire, Daly Draw and Walker Webster channels will be directed into an underground culvert and isolated from waste rock. Mine waste removed from channels and trails will be transported to a regulated offsite treatment and disposal (T&D) facility. Approximately 4,500 linear feet of channel will be remediated in lower Empire Canyon. Approximately 2,500 feet of recreational trail may be remediated throughout Empire

Canyon. In addition, remedial activities will be conducted in areas containing significant amounts of impacted waste rock (e.g. Alliance mine dump and Daly West). The Site will be monitored to ensure that the remediation is effective in improving the environmental quality of the Site. Institutional controls will be implemented as required for the protection of Site workers and recreational users. Best Management Practices will be followed during all remedial activities. The Site will be monitored for five years to ensure that the environmental quality of the Site is not degrading.

Implementing Waste Removal with UPCM Offsite Property Disposal would comply with ARARs.

Effectiveness: Implementation of Alternative 5 is technically feasible. The removal of mine waste will reduce the environmental exposures of metals onsite to surface water, Site workers and recreational users. The removal of mine waste from the Empire and Walker Webster channels will prevent the leaching of metals into surface water. The removal of impacted mine wastes from recreation trails will prevent recreational users from being exposed to heavy metals.

Implementability: Alternative 5 is technically feasible to implement with no anticipated technical difficulties. Services required will include a remedial construction contractor familiar with the anticipated environmental conditions at the Site and a transportation company to transport the material to a T&D facility. Over 3,500 truck loads of materials will have to be transported through the heavily congested town of Park City, this might cause some adverse public opinion and potentially put the public at risk due to increased traffic and material spillage. Materials required will include clay liner material, culvert material and clean fill material, all of which are readily available.

Cost: Cost estimates for implementation of Alternative 5 are presented in Table 5. The total estimated cost for implementing Waste Removal with Offsite Treatment and Disposal is estimated to be $3,672,731.08. The high cost of this alternative will may make it difficult to implement.

10.0 COMPARATIVE RESPONSE ACTION ALTERNATIVES

This section provides a comparative analysis of the five proposed response action alternatives discussed in Section 8.0. The ability of each proposed response action alternative to meet the criteria of effectiveness, implementability and cost is compared. Advantages and disadvantages of each alternative and key tradeoffs are discussed and are also provided in summary form in Table 6.

10.1 Effectiveness Criteria

Each of the alternatives are comparatively analyzed to determine which alternative(s) are the most effective in obtaining compliance with the RAO's.

The RAO to minimize human exposure to mine wastes is:

- Minimize the potential for human exposure to elevated lead and arsenic concentrations on recreational trails.

Alternative 1 (No Action): This alternative would not be consistent with the development agreement between United Park and Park City Municipal Corporation. Under certain exposure scenarios this alternative may not be effective in achieving the RAO. Alternative 2 (Institutional Controls): This alternative would not be consistent with the development agreement between United Park and Park City Municipal Corporation. Under certain exposure scenarios this alternative may not be effective in achieving the RAO.

Of the three alternatives (Alternatives 3, 4 and 5) that address removal of mine wastes all three alternatives provide the same level of exposure reduction and therefore would be effective at meeting the RAO. The difference in the alternatives is related to the disposal of the material. Alternatives 4 and 5 are less effective given additional potential for material spillage during transportation. Alternative 3, Waste Isolation with Onsite Repository would achieve the response objective most cost-effectively.

Metals in Surface Water: As stated in Section 3.0 the highest concentrations of metals in surface water are located in the vicinity of and down gradient from the confluence of Walker Webster Gulch and in upper Empire Canyon below the Daly West mine dump.

The RAO to reduce metals concentrations in surface water is:

- Isolate surface water from mine wastes in lower Empire Canyon.

Alternatives 1 and 2 of the proposed response actions do not meet this objective and therefore would not be effective. These alternatives were designed as a baseline (Alternative 1) and to monitor the Site for potential further degradation of environmental conditions (Alternative 2). Alternatives 3, 4 and 5 of the proposed response actions meet this objective.

Of the three alternatives that address isolation of surface water from mine wastes all three alternatives would provide the same level of surface water isolation. The difference in the alternatives is related to the disposal of the excavated material. Alternative 3, Waste Isolation with Onsite Repository would achieve the response objective most cost-effectively.

10.2 Implementability Criteria

Technical Feasibility: All of the alternatives are technically feasible to implement, with varying degrees of difficulty. All of the alternatives use well-established methods and protocols.

The difficulty of implementation increases with each alternative, e.g. Alternative 1 is easier to implement then Alternative 2 and so forth.

Permitting requirements increase with each alternative, e.g., Alternative 3 is easier to permit than Alternative 4 and so forth. Alternatives 3 through 5 involve the movement of materials. Alternative 3 involves the movement of mine wastes on UPCM property, which would require regulatory approval. Alternatives 4 and 5 involve the transportation of mine waste offsite. Mine waste would have to be transported through the congested streets of Park City. The offsite transportation proposed Alternatives 4 and 5 add the potential for material spillage.

Transportation of material through Park City may not be publicly acceptable. In addition, Alternative 5 would involve the selection of an offsite licensed waste disposal site.

10.3 Costs

Estimated costs for alternatives 1 through 5, from least expensive to most are provided below:

Alternative	Estimated Cost
Alternative 1 – No Action	none
Alternative 2 - Institutional Controls and Site Monitoring	$ 367,200.00
Alternative 3 - Waste Isolation with Onsite Repository	$ 1,093,554.49
Alternative 4 - Waste Removal with UPCM Offsite Property Disposal	$ 1,354,171.63
Alternative 5 - Waste Removal with Offsite Treatment and Disposal	$ 3,672,731.08

10.4 Comparisons

Table 6 presents a comparison of the five proposed alternatives. Implementing Alternatives 1 and 2 would provide no further improvement in surface water quality. Alternatives 2 through 5 were designed to monitor conditions at the Site. The difference in these alternatives is in the level of human exposure to mine wastes. Alternative 1 provides no reduction in human exposure. Alternative 2 provides a reduction in human exposure by avoidance. However the quality of the environment is not improved under Alternative 2, as it is by the removal of mine waste detailed in Alternatives 3 through 5.

Alternatives 3 through 5 provide a similar level of protection to onsite human health and the Site environment. The difference in these alternatives is mainly concerned with, logistics, disposal options and costs. Each of these alternatives would achieve identical onsite goals. However, Alternatives 4 and 5 require the transportation of material through the town of Park City, this could increase the potential for human contact through material spillage.

11.0 RECOMMENDED RESPONSE ACTION ALTERNATIVE

This section provides a recommendation for the preferred Response Action Alternative for Empire Canyon.

The Recommended Response Action for the Site is a combination of Alternative 3, Waste Isolation with Onsite Repository and Alternative 4, Waste Isolation with UPCM property (Richardson Flat) Offsite Disposal. This response action will isolate surface water from mine wastes in Empire Canyon and minimize the potential for human exposure to elevated lead and arsenic concentrations on recreational trails. This action provides the best balance between providing the highest degree of protectiveness and cost effectiveness in a logistically straightforward manner.

11.1 Recommended Response Action Description

The Recommended Response Action, Waste Isolation and Removal with Onsite Repository and UPCM Offsite Property Disposal involves isolating areas of mine waste from the environment. Certain areas in Empire Canyon and Walker Webster Gulch contain significant amounts of mine wastes in the channels that will be excavated. The channels will be reconstructed using clean rip-rap material and/or culverts. Some segments of the channels may also be lined with a clay liner to keep water on the surface. Recreational trails will be remediated to to be consistent with the development agreement and some of the trails may also be rerouted. The Daly West mine dump will be recontoured and covered with clean material. In certain areas surface water flow in the vicinity of the Daly West mine dump will be re-routed to minimize contact with waste rock. A cut-off ditch will be placed on the upgradient side of the dump. Surface water from the Empire, Daly Draw and Walker Webster channels may be directed into culverts in key areas to isolate the surface water from waste rock.

Mine waste removed from channels and trails will be disposed of using the following two methods:

1) A portion of the waste will be placed in an onsite repository. The onsite repository will be constructed using a clay liner and then will be covered to isolate the waste from the environment.

2) Any remaining waste will be transported to and disposed of at Richardson Flat. Richardson Flat is a mine tailings site owned by UPCM. The material is similar to that at Richardson Flat and will be contained within the tailings impoundment, which is currently the subject of a Remedial Investigation and Feasibilty Study.

Approximately 4,500 linear feet of channel will be remediated in lower Empire Canyon. Approximately 2,500 feet of recreational trail may be remediated throughout Empire Canyon. In addition, remedial activities will be conducted in areas containing significant amounts of impacted waste rock (e.g. Alliance mine dump and Daly West). These areas will be regraded and capped with clean material. The Site will be monitored for five years to ensure that the remediation is effective in improving the environmental quality of the Site. Institutional controls will be implemented as required for the protection of Site workers and recreational users. Best Management Practices will be followed during all remedial activities.

Implementing Waste Removal with UPCM Onsite and Offsite Property Disposal is considered to be protective of the environment and would comply with ARARs.

Effectiveness: Implementation of the Recommended Response Action is technically feasible. The removal of mine waste will reduce the environmental exposures of metals onsite to surface water, Site workers and recreational users. The removal of mine waste from the Empire and Walker Webster channels will prevent the leaching of metals into surface water. The removal of impacted mine wastes from recreation trails will prevent recreational users from being exposed to heavy metals.

Implementability: The Recommended Response Action is technically feasible to implement with no anticipated technical difficulties. Services required will include a remedial construction contractor familiar with the anticipated environmental conditions at the Site and a transportation company to transport the material to Richardson Flat which is located approximately six miles away. Approximately 300 truck loads of materials will have to be transported through the town of Park City, which will require strict adherence to traffic regulations, proper covering of the loads, and safety inspections of hauling equipment. Materials required will include clay liner material, culvert material and clean fill material, all of which are readily available.

Cost: Estimated costs for implementation of the combined Recommended Response Actions are presented in Table 7. The estimated total cost for implementing the combined Waste Removal with UPCM Onsite and Offsite Property Disposal is $1,174,752.94.

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Tabbed Page: Figures

Color Map(s)

The following pages contain color that does not appear in the scanned images.

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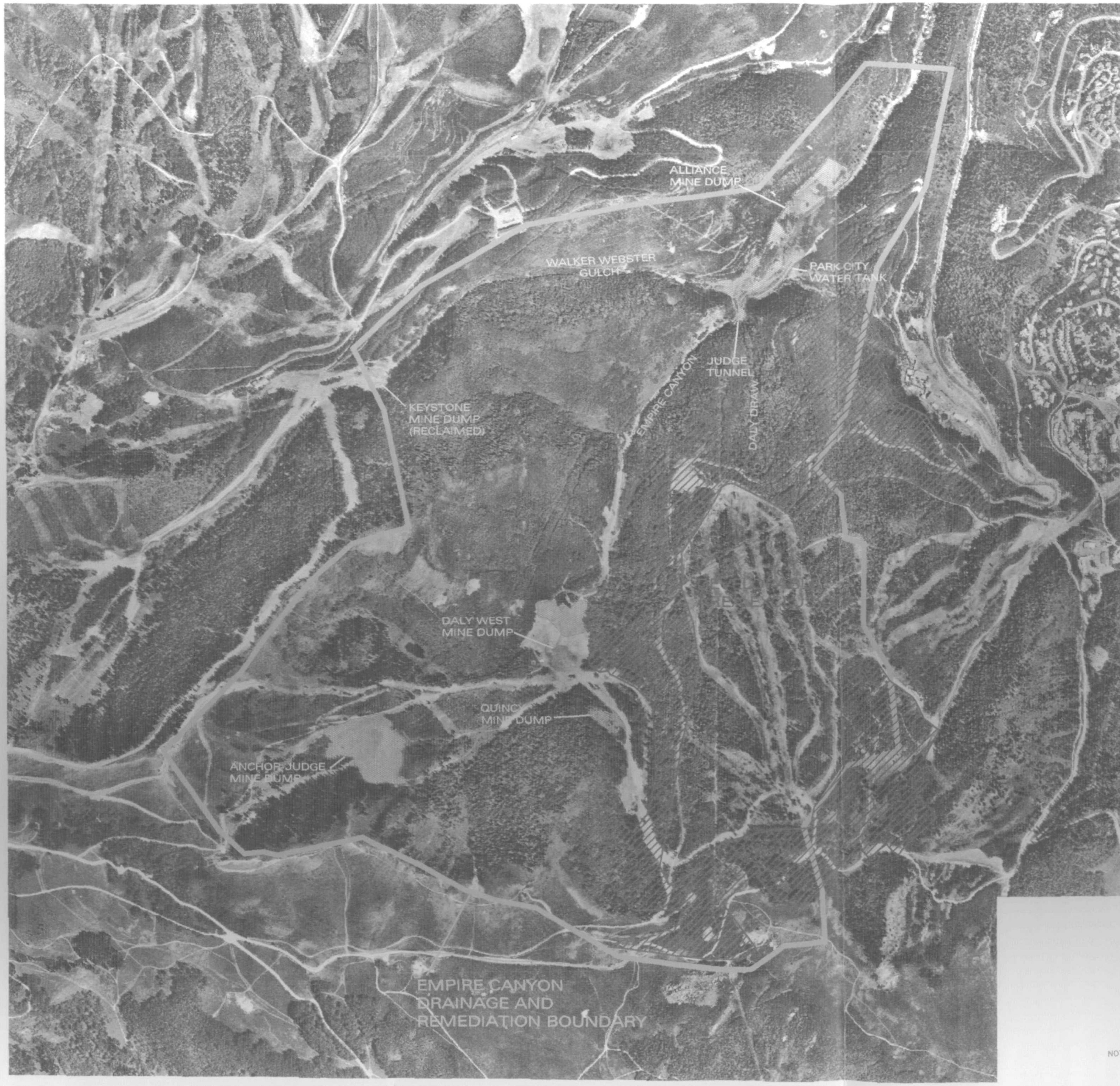

LEGEND

SITE BOUNDARY

MINE WASTE AREA

DEVELOPABLE AREA EXCLUSIONS

NOT TO SCALE

N

UNITED PARK CITY MINES

FIGURE 1
EMPIRE CANYON
SITE MAP

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

JUNE 2003

GEOREF-AERIAL-3

UNITED PARK CITY MINES

FIGURE 2
EMPIRE CANYON
REMEDIAL DESIGN SCHEMATIC

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

JUNE 2003

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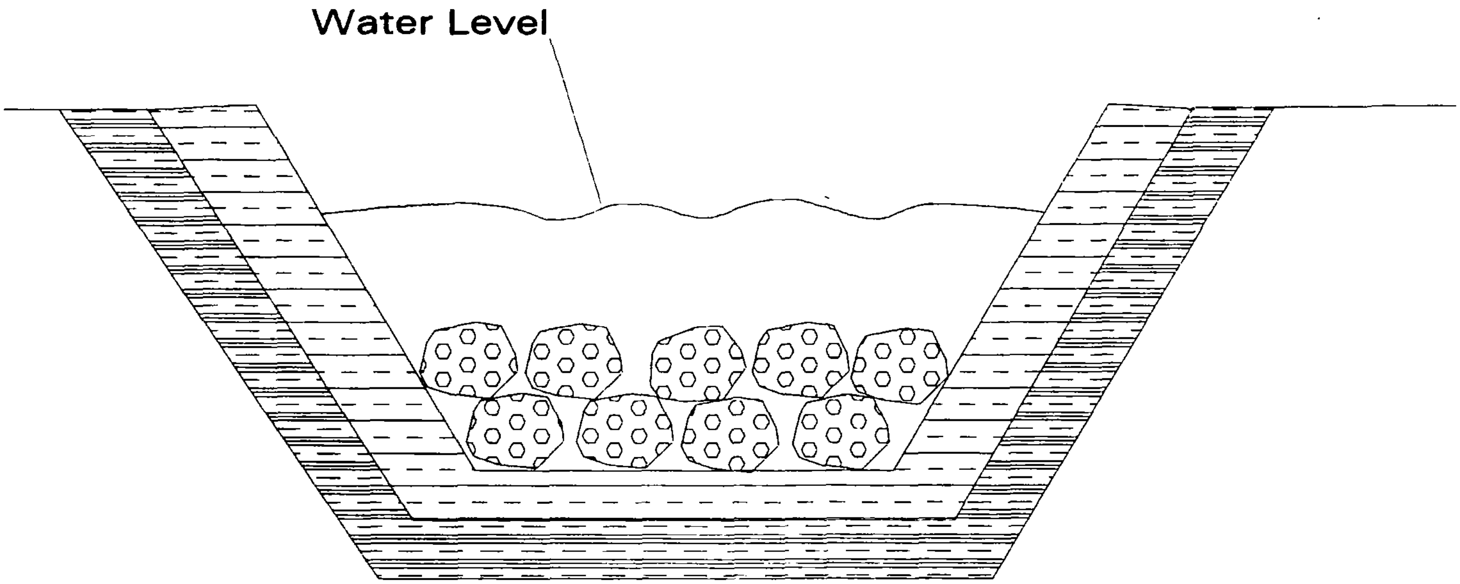

LEGEND

Clay Liner (Approx. 6" thick)

Gravel Filter Blanket (Approx. 6" to 12" thick)

Rip-rap (Approx. 12" of material)

NOT TO SCALE

UNITED PARK CITY MINES

FIGURE 3
TYPICAL CHANNEL
SCHEMATIC CROSS SECTION

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST
SUITE 2A
MIDVALE, UT 84047
801-255-2626

June 2003

channel cross section.dwg

UNITED PARK CITY MINES

FIGURE 4
REPOSITORY LOCATION

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

June 2003

repository location

Tabbed Page: Tables

Table 1
Potential Chemical Specific ARARs

Requirement	Citation	Description	Determination	Comment
Definitions and General Requirements of Utah Water Quality Act	UAC R317-1	Provides definitions and general requirements for waste discharges to waters of the State of Utah	Potentially Applicable	Potentially applicable to point source discharges of contaminants into Silver Creek (if any).
Utah Surface Water Quality Standards	UAC R317-2-6 UAC R317-2-13 UAC R317-2-14	Establishes use designations for Silver Creek (as tributary to the Weber River): Class 1C - Protected for domestic purposes with prior treatment processes as required by Utah Div. of Drinking Water. Class 2B - Protected for secondary contact recreation such as boating, wading. Class 3A - Protected for cold water species of game fish and aquatic life. Class 4 - Protected for agricultural uses and stock watering	Potentially Applicable	Potentially applicable to point source discharges of contaminants into Silver Creek (if any).
Groundwater Quality Standards	UAC R317-6-2	Establishes state groundwater quality standards	Potentially Relevant and Appropriate	Potentially relevant and appropriate to any discharges of contaminants to ground water (if any).
Utah Storm Water Rules	UAC R317-8-3.9	Establishes state storm water requirements	Applicable	UPCM shall continue to implement best management practices to address storm water management at the Site. Covers for potential source materials in certain areas will be subject to UPCM's development agreement with Park City.

Table 1 (continued)
Potential Location Specific ARARs

Requirement	Citation	Description	Determination	Comment
Protection of Wetlands	33 USC § 1344	Prohibits discharge of dredged or fill materials into waters of the United States.	Potentially Applicable	Measures will be developed to avoid, restore, or mitigate impacts to jurisdictional wetlands, if any.
Historic Sites, Building and Antiquities Act	16 USC §§ 461-467	Requires protection of landmarks listed on National Registry	Applicable	Proposed activities will not adversely affect natural landmarks
National Historic Preservation	16 USC § 470	Requires protection of district, site, building, structure or object eligible for inclusion in national register of historic places	Applicable	Proposed activities will not adversely affect any such district, site, building, structure or object
Archeological and Historic Preservation Act	16 USC § 469	Requires preservation of significant historical and archeological data	Applicable	Proposed activities will not adversely affect archeological data or landmarks
Fish and Wildlife Coordination Act	16 USC § 1531 *et seq*	Requires that actions taken in areas that may affect streams and rivers be undertaken in a manner that protects fish and wildlife	Applicable	USFWS has been consulted with regard to actions impacting Silver Creek
Endangered Species Act	16 USC § 1531	Requires protection of endangered and threatened species	Applicable	USFWS has been consulted with regard to protection of endangered and threatened species.
Migratory Bird Treaty Act	16 USC § 703 *et seq*	Requires protection of migratory nongame birds	Applicable	USFWS has been consulted with regard to protection of migratory nongame birds.
RCRA Subtitle D Solid Waste Requirements	UAC R315-301 *et seq* ***Specific requirements should be assessed***	Establishes requirements for construction and operation of solid waste landfills.	Potentially Relevant and Appropriate	Potentially relevant and appropriate to onsite repository under Alternative 3. Otherwise not relevant and appropriate except to the extent that these rules may apply to off-site solid waste facilities at which certain Bevill-exempt solid wastes may be disposed (including the disposal of materials at Richardson Flat as described in Alternative 4)..

Table 1 (continued)
Potential Action Specific ARARs

Requirement	Citation	Description	Determination	Comment
Air Pollution	UAC R307-101 *et seq*	General requirements for compliance with National Ambient Air Quality Standards (NAAQS)	Potentially Applicable	Potentially applicable to earth moving, grading, and excavating activities that may result in release of contaminants to air.
Fugitive Dust Control	UAC R307-205-5 UAC R307-205-6	Establishes requirements for fugitive dust, construction activities, and roadways associated with mining and tailings piles and ponds	Potentially Applicable	Potentially applicable to earth moving, grading, and excavating activities that may result in dust.
RCRA Subtitle C Hazardous Waste Requirements	UAC R315-1 *et seq*	Establishes requirements for disposal of hazardous wastes	Not Applicable or Relevant and Appropriate	Not applicable or relevant and appropriate because response actions will only address Bevill-exempt solid wastes.

Table 2
Cost Estimate
Alternative 2, Institutional Controls

Direct Capitol Costs	Quantity	Unit	Cost	Total Cost	
Trail Signage	100	sign	$50.00	$5,000.00	
Fencing	2000	lf	$25.00	$50,000.00	
Site Monitoring Plan	1		$7,500.00	$7,500.00	
Health and Safety Plan	1		$7,500.00	$7,500.00	
Develop Institutional Controls	1		$10,000.00	$10,000.00	
		Subtotal		**$80,000.00**	
Long-Term Operation and Maintenance Costs					
O&M	5	yr	$5,000.00	$25,000.00	
Annual Sampling	5	yr	$2,000.00	$10,000.00	
Reporting	5	yr	$5,000.00	$25,000.00	
Institutional Controls Monitoring and Repair	30	yr	$5,000.00	$150,000.00	
		Subtotal		**$210,000.00**	
			Total Direct Costs		**$290,000.00**
Indirect Capitol Costs					
Project Administration				$25,000.00	
Contingency (15 % of Direct Capitol Cost)				$43,500.00	
Health and Safety (3 % of Capitol Costs)				$8,700.00	
		Subtotal		**$77,200.00**	
			Total Indirect Costs		**$77,200.00**
	TOTAL COSTS				**$367,200.00**

Table 3
Cost Estimate
Alternative 3, Waste Isolation, Onsite Repository

Direct Capitol Costs	Quantity	Unit	Cost	Total Cost	
Trail Reconstruction					
Trail reconstruction grading and soil import	740	cy	$15.00	$11,100.00	
		Subtotal		**$11,100.00**	
Daly West Mine Dump					
Channel Construction (exc, compact, construct)	667	cy	$13.29	$8,864.43	
Clay for channel lining (import,screen, place)	444	cy	$13.29	$5,900.76	
Grade Fill From development	16800	cy	$2.00	$33,600.00	
revegetation	6.92	ac	$2,500.00	$17,300.00	
Extend Storm Drain	235	lf	$50.00	$11,750.00	
Contour remaining dump	40	hrs	$140.00	$5,600.00	
		Subtotal		**$83,015.19**	
Channel Reconstruction (lower Empire)					
Exc tails/waste, reconstruct, line w. clay, haul to rep.	16869	cy	$13.76	$232,117.44	
Final grade on channel, add topsoil	17187	cy	$8.82	$151,589.34	
Rip-Rap & Checkdams	510	cy	$5.50	$2,805.00	
Dust Control (for excavation and repository)	20	days	$735.00	$14,700.00	
3 way junction box	1	each	$3,000.00	$3,000.00	
revegetation	8	ac	$2,500.00	$20,000.00	
		Subtotal		**$424,211.78**	
Repository (Costs to place and compact material included in above costs)					
Construct repository, excavate & line w. clay & compact	1462	cy	$4.50	$6,579.00	
topsoil	375	cy	$12.00	$4,500.00	
revegetate	2	ac	$2,500.00	$5,000.00	
		Subtotal		**$16,079.00**	
Long-Term Operation and Maintenance Costs					
O&M	5	yr	$4,000.00	$20,000.00	
Annual Sampling	5	yr	$2,000.00	$10,000.00	
Reporting	5	yr	$5,000.00	$25,000.00	
Develop Institutional Controls	1		$10,000.00	$10,000.00	
Institutional Controls Monitoring and Repair	30	yr	$2,000.00	$60,000.00	
		Subtotal		**$125,000.00**	
			Total Direct Costs		**$659,405.97**
Indirect Capitol Costs					
Engineering Design and Project Administration				$50,000.00	
Monitoring Plan				$4,000.00	
Construction Oversight (7.5 % of Direct Capitol Cost)				$49,455.45	
Contingency (15 % of Direct Capitol Cost)				$98,910.90	
Health and Safety (3 % of Capitol Costs)				$19,782.18	
EPA Oversight				$150,000.00	
State Oversight				$12,000.00	
Construction Oversight				$50,000.00	
		Subtotal		**$434,148.52**	
			Total Indirect Costs		**$434,148.52**
	TOTAL COSTS				**$1,093,554.49**

Table 4
Cost Estimate
Alternative 4, Waste Isolation, Richardson Flat Disposal

Direct Capitol Costs	Quantity	Unit	Cost	Total Cost	
Trail Reconstruction					
Trail reconstruction grading and soil import	740	cy	$15.00	$11,100.00	
		Subtotal		**$11,100.00**	
Daly West Mine Dump					
Channel Construction (exc, compact, construct)	667	cy	$13.29	$8,864.43	
Clay for channel lining (import,screen, place)	444	cy	$13.29	$5,900.76	
Grade Fill From development	16800	cy	$2.00	$33,600.00	
revegetation	6.92	ac	$2,500.00	$17,300.00	
Extend Storm Drain	235	lf	$50.00	$11,750.00	
Contour remaining dump	40	hrs	$140.00	$5,600.00	
		Subtotal		**$83,015.19**	
Channel Reconstruction (lower Empire)					
Exc tails/waste, reconstruct, line w. clay, haul to rep.	16869	cy	$13.76	$232,117.44	
Final grade on channel, add topsoil	17187	cy	$8.82	$151,589.34	
Rip-Rap & Checkdams	510	cy	$5.50	$2,805.00	
Dust Control (for excavation and repository)	20	days	$735.00	$14,700.00	
3 way junction box	1	each	$3,000.00	$3,000.00	
revegetation	8	ac	$2,500.00	$20,000.00	
		Subtotal		**$424,211.78**	
Richardson Flat Disposal					
Hual to Richardson	16869	cy	$8.74	$147,435.06	
Place/compact wastes & cover	16869	cy	$3.00	$50,607.00	
Dust Control	20	days	$735.00	$14,700.00	
topsoil	500	cy	$12.00	$6,000.00	
revegetate	2	ac	$2,500.00	$5,000.00	
		Subtotal		**$223,742.06**	
Long-Term Operation and Maintenance Costs					
O&M	5	yr	$4,000.00	$20,000.00	
Annual Sampling	5	yr	$2,000.00	$10,000.00	
Reporting	5	yr	$5,000.00	$25,000.00	
Develop Institutional Controls	1		$10,000.00	$10,000.00	
Institutional Controls Monitoring and Repair	30	yr	$2,000.00	$60,000.00	
		Subtotal		**$125,000.00**	
			Total Direct Costs		**$867,069.03**
Indirect Capitol Costs					
Engineering Design and Project Administration				$50,000.00	
Monitoring Plan				$4,000.00	
Construction Oversight (7.5 % of Direct Capitol Cost)				$65,030.18	
Contingency (15 % of Direct Capitol Cost)				$130,060.35	
Health and Safety (3 % of Capitol Costs)				$26,012.07	
EPA Oversite				$150,000.00	
State Oversite				$12,000.00	
Construction Oversite				$50,000.00	
		Subtotal		**$487,102.60**	
			Total Indirect Costs		**$487,102.60**
	TOTAL COSTS				**$1,354,171.63**

Table 5
Cost Estimate
Alternative 5, Waste Isolation, regulated Disposal Site

Direct Capitol Costs	Quantity	Unit	Cost	Total Cost	
Trail Reconstruction					
Trail reconstruction grading and soil import	740	cy	$15.00	$11,100.00	
		Subtotal		**$11,100.00**	
Daly West Mine Dump					
Channel Construction (exc, compact, construct)	667	cy	$13.29	$8,864.43	
Clay for channel lining (import,screen, place)	444	cy	$13.29	$5,900.76	
Grade Fill From development	16800	cy	$2.00	$33,600.00	
revegetation	6.92	ac	$2,500.00	$17,300.00	
Extend Storm Drain	235	lf	$50.00	$11,750.00	
Contour remaining dump	40	hrs	$140.00	$5,600.00	
		Subtotal		**$83,015.19**	
Channel Reconstruction (lower Empire)					
Exc tails/waste, reconstruct, line w. clay, haul to rep.	16869	cy	$13.76	$232,117.44	
Final grade on channel, add topsoil	17187	cy	$8.82	$151,589.34	
Rip-Rap & Checkdams	510	cy	$5.50	$2,805.00	
Dust Control (for excavation and repository)	20	days	$735.00	$14,700.00	
3 way junction box	1	each	$3,000.00	$3,000.00	
revegetation	8	ac	$2,500.00	$20,000.00	
		Subtotal		**$424,211.78**	
Regulated Facilty Disposal					
Hual to Loadout	16869	cy	$8.74	$147,435.06	
Load	16869	cy	$2.00	$33,738.00	
Hual to East Carbon	16869	cy	$6.17	$104,081.73	
Disposal fees (assumes one half will fail TCLP)	16869	cy	$105.00	$1,771,245.00	
Dust Control (for excavation and loading)	20	days	$735.00	$14,700.00	
		Subtotal		**$2,071,199.79**	
Long-Term Operation and Maintenance Costs					
O&M	5	yr	$4,000.00	$20,000.00	
Annual Sampling	5	yr	$2,000.00	$10,000.00	
Reporting	5	yr	$5,000.00	$25,000.00	
Develop Institutional Controls	1		$10,000.00	$10,000.00	
Institutional Controls Monitoring and Repair	30	yr	$2,000.00	$60,000.00	
		Subtotal		**$125,000.00**	
			Total Direct Costs		**$2,714,526.76**
Indirect Capitol Costs					
Engineering Design and Project Administration				$50,000.00	
Monitoring Plan				$4,000.00	
Construction Oversight (7.5 % of Direct Capitol Cost)				$203,589.51	
Contingency (15 % of Direct Capitol Cost)				$407,179.01	
Health and Safety (3 % of Capitol Costs)				$81,435.80	
EPA Oversite				$150,000.00	
State Oversite				$12,000.00	
Construction Oversite				$50,000.00	
		Subtotal		**$958,204.32**	
			Total Indirect Costs		**$958,204.32**
	TOTAL COSTS				**$3,672,731.08**

Table 6
Comparison of Action Alternatives

Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls and Site Monitoring	Alternative 3 Waste Isolation, Onsite Repository	Alternative 4 Waste Isolation, UPCM Property Disposal	Alternative 5 Waste Isolation, Offsite Disposal
Effectiveness					
RA Objective 1: Isolation of surface water from mine wastes in Empire Canyon, consistent with Best Management Practices	Not effective, baseline conditions.	Not effective, Site will be monitored for further degradation of surface water.	Effective, surface water will be isolated from mine wastes in channels	Effective, surface water will be isolated from mine wastes in channels	Effective, surface water will be isolated from mine wastes in channels
RA Objective 2: Minimizing the potential for human exposure to elevated lead and arsenic concentrations on recreational trails	Not effective, baseline conditions.	Moderately effective, site users will be re-routed when possible and site workers will be trained to avoid metals hazrads	Effective, mine wastes over remedial goals will be removed from trails and construction areas.	Effective, mine wastes over remedial goals will be removed from trails and construction areas.	Effective, mine wastes over remedial goals will be removed from trails and construction areas.
Implementabilty					
Technically feasible	Yes	Yes	Yes	Yes	Yes
Availibility of Goods and Services	No services required	All goods and services are availible.	All goods and services are availible.	All goods and services are availible.	All goods and services are availible.
Difficulty	Nothing to implement.	Not difficult, monitoring program will be similar to other UPCM sites.	Least difficult of waste isolation options. Material will not be transported offsite. Repository will have to be constructed according to regulations.	More difficult than Alternative 3. Material will have to be transported approximately 6 miles through Park City.	Most difficult of waste isolation alternatives. Thrid party waste disposal and/or treatment contractor will be used. Greatest transportation distance and logistics.
Impacts to Site Users and Public	Impacts to public are related to Silver Creek water quality. Environmental impacts to site users remains as is.	Impacts to site users will depend on users abiding by posted regualtions and avioding areas of mine waste.Impacts to public are related to Silver Creek water quality.	Impacts to Site users are minimized. Impacts to public is minimal no materials transported off site. Least amouont of public disruption of waste isolation alternatives.	Impacts to Site users are minimized. Impacts to public is consists of transporting 700+ loads of material through congested Park City streets.	Impacts to Site users are minimized. Impacts to public is consists of transporting 700+ loads of material through congested Park City streets.
Administrative Feasibility					
Public Acceptance	Not likely	Not likely-trails may be rerouted and/or closed	Likely, public may need to be educated about repository.	Less likely than Alternative 3. Alternative will increase truck traffic in Park City.	Less likely than Alternative 3. Alternative will increase truck traffic in Park City.
Regulatory Acceptance	Not likely	Not likely	possible	possible	possible
Cost	$0.00	$367,200.00	$1,093,554.49	$1,354,171.63	$3,672,731.08

Table 7
Cost Estimate
Recommended Response Action, Waste Isolation, Onsite Repository and Richardson Flat Disposal

Direct Capitol Costs	Quantity	Unit	Cost	Total Cost	
Trail Reconstruction					
Trail reconstruction grading and soil import	740	cy	$15.00	$11,100.00	
		Subtotal		**$11,100.00**	
Daly West Mine Dump					
Channel Construction (exc. compact, construct)	667	cy	$13.29	$8,864.43	
Clay for channel lining (import,screen, place)	444	cy	$13.29	$5,900.76	
Grade Fill From development	16800	cy	$2.00	$33,600.00	
revegetation	6.92	ac	$2,500.00	$17,300.00	
Extend Storm Drain	235	lf	$50.00	$11,750.00	
Contour remaining dump	40	hrs	$140.00	$5,600.00	
		Subtotal		**$83,015.19**	
Channel Reconstruction (lower Empire)					
Exc tails/waste, reconstruct, line w. clay, haul to rep.	16869	cy	$13.76	$232,117.44	
Final grade on channel, add topsoil	17187	cy	$8.82	$151,589.34	
Rip-Rap & Checkdams	510	cy	$5.50	$2,805.00	
Dust Control (for excavation and repository)	20	days	$735.00	$14,700.00	
3 way junction box	1	each	$3,000.00	$3,000.00	
revegetation	8	ac	$2,500.00	$20,000.00	
		Subtotal		**$424,211.78**	
Repository (Costs to place and compact material included in above costs)					
Construct repository, excavate & line w. clay & compact	1170	cy	$4.50	$5,265.00	
topsoil	300	cy	$12.00	$3,600.00	
revegetate	1.5	ac	$2,500.00	$3,750.00	
		Subtotal		**$12,615.00**	
Richardson Flat Disposal (Below Tank)					
Hual to Richardson	4554	cy	$8.74	$39,801.96	
Place/compact wastes & cover	4554	cy	$3.00	$13,662.00	
Dust Control	10	days	$735.00	$7,350.00	
topsoil	300	cy	$12.00	$3,600.00	
revegetate	1.5	ac	$2,500.00	$3,750.00	
		Subtotal		**$68,163.96**	
Long-Term Operation and Maintenance Costs					
O&M	5	yr	$4,000.00	$20,000.00	
Annual Sampling	5	yr	$2,000.00	$10,000.00	
Reporting	5	yr	$5,000.00	$25,000.00	
Develop Institutional Controls	1		$10,000.00	$10,000.00	
Institutional Controls Monitoring and Repair	30	yr	$2,000.00	$60,000.00	
		Subtotal		**$125,000.00**	
			Total Direct Costs		**$724,105.93**
Indirect Capitol Costs					
Engineering Design and Project Administration				$50,000.00	
Monitoring Plan				$4,000.00	
Construction Oversight (7.5 % of Direct Capitol Cost)				$54,307.94	
Contingency (15 % of Direct Capitol Cost)				$108,615.89	
Health and Safety (3 % of Capitol Costs)				$21,723.18	
EPA Oversite				$150,000.00	
State Oversite				$12,000.00	
Construction Oversite				$50,000.00	
		Subtotal		**$450,647.01**	
			Total Indirect Costs		**$450,647.01**
	TOTAL COSTS				**$1,174,752.94**

Tabbed Page: Appendix A

Appendix A
Empire Canyon Site Characterization Report

DRAFT SITE CHARACTERIZATION REPORT
FOR
EMPIRE CANYON

EPA ID No. 0002005981

March 3, 2003

Prepared for:

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Prepared by:

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1.0 INTRODUCTION

This Site Characterization Report is a compilation of all pertinent data for the United Park City Mines (United Park) Empire Canyon Site (Site), an inactive mine and milling area near Park City, Utah. United Park is conducting an Engineering Evaluation and Cost Analysis (EECA) pursuant to an Administrative Order on Consent (AOC), dated May 14, 2002. The data presented in this report will be used as a component of the Engineering Evaluation/Cost Analysis (EE/CA) for the Site.

There have been multiple investigations of mine wastes conducted in Empire Canyon over the past several years. In 1999, The Upper Silver Creek Watershed Stakeholders Group (USCWG) was formed to evaluate hazardous substance impacts to the Silver Creek Watershed. In the spring and fall of 2000 UPCM working as a partner in the watershed group collected sediment and surface water samples. Based on the data collected in 2000 the watershed group determined that the Empire Canyon drainage was a potentially major source of zinc loading to Silver Creek. In 1999 the Utah Division of Water Quality (UDWQ) determined that water quality in Silver Creek was impaired. Pursuant to Section 303(d) of the Clean Water Act as amended, each State is required to identify those water bodies for which existing pollution controls are not stringent enough to implement state water quality standards. Silver Creek was placed on the UDWQ 303(d) list in 1998 for exceedances of the zinc water quality standards. In April of 2000, the Silver Creek listing was amended to include cadmium. Presently, the UDWQ is completing its' TMDL analysis and a report will be prepared sometime in 2002.

In the spring and fall of 2001 DERR conducted an Expanded Site Investigation. Soil, sediment and Surface water samples were collected in 2001.

In addition to the two previously discussed investigations samples have been collected at various locations throughout the Site from 1999 through 2002.

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A Data Validation Report is presented in Appendix 1. The Data Validation Report assess the validity of data collected for this Site Characterization Report. The data collected as part of the USCWG study and DERR ESI has been validated as part of those studies. Laboratory analytical reports are provided in Appendix 2.

2.0 SITE DESCRIPTION

The Empire Canyon site is a historic ore mining and processing area located near Park City, Summit County, Utah. Empire Canyon is located south of Park City. Surface water flow from Empire Canyon occurs in a small ephemeral channel (DERR, 2001). The site is situated on the eastern slope of the Wasatch Range, approximately 25 miles east of Salt Lake City. Park City rests at the downstream end of Empire Canyon.

The geographic coordinates for the site are 40 degrees 38'40.0' north latitude and 111 degrees 29' 38.5" west longitude (Thiros, 2000). To reach the site, travel south on Main Street in Park City. Travel past the houses until the paved road changes to gravel, this is the beginning of the canyon. There were several mines, a concentrator, assay office, trams and other surface mine features in the canyon up to the drainage divide (Figure 1).

Waste rock from the mine operations are located on the slopes in the canyon as well as in the creek. Several hiking/biking trails parallel the creek and traverse the mill and mine sites. The canyon and the creek are popular areas for residents and visitors to hike and mountain bike. The Empire Canyon drainage originates approximately one mile to the south near the Summit/Wasatch County line.

2.0 PREVIOUS INVESTIGATIONS

This section presents the previous site characterization data collected in Empire Canyon. Previous investigations have focused on impaired surface water quality occurring during the spring snowmelt season and potential human health risks associated with historic mine wastes problems. The analytical data is presented in Tables 1 through 10. Soil sample locations are presented in Figure 2. Surface water sample locations are presented in Figure 3. Sediment sample locations that were collocated with the surface water sample locations are presented in Figure 3.

2.1 Upper Silver Creek Watershed Sampling Results Spring and Fall, 2000

As part of the watershed group UPCM conducted water and sediment sampling in the spring and fall of 2000 in the Silver Creek watershed including Empire Canyon. . In May and June of 2000 water quantity and quality data were collected from the Empire Canyon watershed divide to its' confluence with the Ontario Canyon drainage. Surface water samples were collected in the lower reaches of the drainage in May and June and in the upper reaches in June of 2000. Sediment samples were collected in Empire Canyon during September of 2000, water samples were not collected in the fall because no water flows later in the season in Empire Canyon. Water flow was measured in Parshall flumes and water quality data were collected at nine locations in the Empire Canyon drainage. The sampling program was initiated to collect data of sufficient quality and quantity to identify potential source areas of contaminants that may be adversely impacting water quality in Silver Creek.

Two analytical summary reports were prepared for the USCWG and were published in July of 2000 (RMC, 2000) and February of 2001 (RMC, 2001).

Data from the spring 2000 sampling event are presented in Table 1. Total zinc concentrations at the site ranged from 0.011 to 5.3 ppm, dissolved zinc concentrations ranged from 0.011 to 5.3 ppm. Total and dissolved arsenic concentrations were below the laboratory detection limits of 0.005 ppm. Total lead concentrations ranged from <0.005 to 0.062 ppm, dissolved lead concentrations ranged from <0.005 to 0.024 ppm. Total cadmium concentrations ranged from <0.001 to 0.046 ppm, dissolved cadmium concentrations ranged from <0.001 to 0.044 ppm.

Based on the data collected in 2000 it appeared that the majority of the metal loading in Empire Canyon occurred between the Judge Tunnel area downstream to the sediment pond (Figure 1).

Three sediment samples were collected during the fall 2000 sampling event. The data indicate that zinc in the sediments ranged from 838 to 11,680 ppm, arsenic in the sediments range from 78 to 513 ppm and lead ranged from 9,025 to 17,120 ppm. Cadmium in the sediments had very little variation in the three samples with concentrations all measured around 60 ppm. Lead was present in the sediments at elevated concentrations but disproportionately low in the surface water as was the case for arsenic.

The samples collected by the USCWG did not indicate a correlation between elevated zinc in surface water and sediments. For example stations USC-15 (Iron Gate Flume) and USC-17 (Judge Tunnel Flume) contained elevated concentrations of zinc in sediments, however the water sample collected at USC-15 contained elevated concentrations of zinc and the sample collected at USC-17 did not contain elevated concentrations of zinc. This is likely due to three factors 1) the relatively low number of sediment samples collected, 2) during the USCWG study sediment samples were not collected in areas where tailings are present in large volumes and 3) areas where elevated surface water concentrations were measured may be receiving much of the metal loading from subsurface flows that are in contact with mine wastes.

In March of 2001 the EPA in cooperation with the USCWG group prepared the "Data Interpretation Report Upper Silver Creek Watershed Surface Water/Stream Sediment Monitoring 2000. In this report EPA and USCWG determined that metals loading from the Empire Canyon drainage required further investigation. In the spring of 2001 DERR and UPCM initiated an Expanded Site Investigation (ESI).

Surface water analytical results for USCWG samples are presented in Table 1. Sediment analytical results for USCWG samples are presented in Table 2. Surface water and sediment sample locations are shown on Figure 3.

2.2 State of Utah Department of Environmental Quality – Division of Environmental Response and Remediation, Expanded Site Inspection, Empire Canyon

The DERR initiated a Expanded Site Inspection (ESI) in the spring of 2001, focus of the ESI was to evaluate contamination exposure and migration pathways associated with ground water, surface water, soil, and air, to determine if human or ecological targets may be exposed through these pathways (DERR, 2001). DERR and UPCM personnel conducted the ESI, the field work was initiated as soon as snowmelt in the canyon provided water to the drainage channel.

Twenty-two (22) surface water samples were collected beginning in the lower reaches of the canyon in late April and culminating with samples at the upper reach of the drainage basin in early July. Total metal samples were collected for the most part, the data are presented in Table 3. Of the twenty-two (22) samples collected eighteen (18) samples were analyzed for total metals and four (4) samples were analyzed for dissolved metal concentrations. Surface water analytical data is presented in Table 3. Total zinc concentrations ranged from 0.001 to 8.87 ppm, dissolved zinc concentrations ranged from 0.582 to 2.35 ppm in the four samples in which dissolved constituents were analyzed.

Tracer tests were conducted by DERR and United Park personnel during the spring runoff period in May and June of 2001. The Tracer Test Report is presented in Appendix 3. The intent of the tracer study was to discern a hydrological connection between the water in the stream channel upstream and downstream from the mine tailing deposits within the Empire Canyon ESI site area (DERR, 2001b). Three (3) tracer studies were conducted in multiple areas of lower Empire Canyon and Walker-Webster Gulch as part of the ESI. The initial tracer study was conducted in a tributary to Empire Canyon at Daly Draw (*See*, Figure 1). The intent of this study was to determine the hydrologic connection between the losing reach of Daly Draw near the flume in the draw and the main Empire Canyon channel downstream of the Judge Tunnel. Results of this study indicate that spring runoff water seeping into ground upstream of the Daly Draw flume enters the Empire Canyon drainage upstream of the Park City Municipal Corporation water tank.

The second tracer study was conducted in the lower reach of Walker-Webster Gulch and in the Empire Canyon channel downstream of the confluence with the gulch. The intent of this study was to determine the hydrologic connection between the losing reach of Walker-Webster and lower Empire Canyon and small ephemeral seeps that occur during the spring runoff in lower Empire Canyon. Results of the study show that there is likely a connection between the Walker-Webster water and the main channel of Empire Canyon. However, the study did not show a postive relationship between the Walker Webster water and the ephemeral seeps that occur near the Empire Channel on a seasonal frequency.

The third tracer study was conducted in the upper reach of Walker-Webster Gulch and the intent of this study was to evaluate the hydrologic connection between the seasonal water and the various losing reaches of the upper section of the gulch. Tracer was injected into the stream above the McConkie ski lift and samples were collected at various points downstream to a point where the gulch turns to the east. Results of the sampling indicated that generally spring runoff from above the McConkie ski lift seeps into the subsurface and resurfaces at various points around and below the reclaimed Keystone Mine. West of the Keystone Mine dump water emerges from a PVC pipe, this water showed a weak hydrologic connection to the tracer injection point. A spring located at the toe of the reclaimed Keystone Mine dump showed a strong hydrologic connection to the upstream tracer injection point. Dye tracer results downstream of the reclaimed Keystone Mine dump did not conclusively show hydrologic connection to the tracer injection point.

As part of the tracer study flow data was collected at the following four (4) flume locations: 1) Middle Empire Canyon, 2) Lower Empire Canyon at the Iron Gate, 3) Daly Draw and 4) Walker Webster Gulch. The DERR flow data presented in Table 4 provides a synopsis of flows during the 2001 spring runoff cycle, a spring typical runoff season. Flow was recorded at the Middle Empire Canyon Flume from May 9 through May 14. The maximum flow recorded at the Middle Empire Canyon Flume was 0.67 cubic feet per second (cfs) on May 14. Flow was recorded at the Iron Gate Flume (Lower Empire Canyon) from April 20 through May 24. Water was still flowing through the flume on May 24, which was the last recorded date at this location. The maximum flow recorded at the Iron Gate Flume was 6.29 cfs on May 18. In addition to surface water flows, the flow at the Iron Gate Flume also contains water from the Judge Tunnel turnout located at the Park City Municipal Water Tank. Flow was recorded at the Daly Draw Flume from April 30 through May 24. The maximum flow recorded at the Daly Draw Flume was 1.74 cubic feet per second (cfs) on May 14. Flow was recorded at the Walker Webster Flume from May 9 through June 7. The maximum flow recorded at the Walker Webster Flume was 2.18 cfs on May 18. Peak flows occurred at all locations during the time period of May 14 though May 18. The data presented above summarizes a typical spring runoff cycle in Empire Canyon and exemplifies the short duration of the annual runoff cycle.

Fifteen (15) sediment samples were collected in the Empire Canyon and related drainages as part of the ESI. Sediment analytical data is presented in Table 5. Zinc concentrations in the sediments ranged from 63.4 to 29,200 ppm, arsenic concentrations ranged from 7.7 to 276 ppm, cadmium concentrations ranged from 0.44 to 165 ppm and lead concentrations ranged from 31.9 to 13,500 ppm.

As part of the ESI twenty-six (26) soil samples from mine waste piles and other areas of interest were collected as part of the ESI. The soil data is presented in Table 6. Lead concentrations in the soils ranged from 27 to 171,000 ppm. Arsenic concentrations in the soils ranged from 10 to 1,170 ppm.

In general high concentrations of metals in surface water can roughly be correlated to high concentrations of metals in sediments. The same correlation can be observed for samples with low concentrations of metals that is low concentrations of metals in surface water can be correlated to low concentrations of metals in sediments. These correlation's are mostly consistent however there are few areas in the site where sediment metal concentrations are low and surface water concentrations are high. Cadmium, lead and zinc sediment and surface water data are compared in Figures 5, 6, and 7, respectively. Although the three figures do not compare all of the analytes that were measured in 2001 by DERR; trends are similar for all three metals. Interestingly there are sample locations where sediment concentrations are similar to those concentration found elsewhere on the site and total metals in the water are elevated as compared to other locations. In these areas the increased concentrations in the surface water is likely due to subsurface flow emanating as springs in and near the main channel. Sediment and water data for sample location EC-SW-07 (*See* Figure 3) demonstrates this trend for all three metals compared. EC-SW-07 is located approximately 300' upstream of the Judge Mine tunnel in Empire Canyon and approximately 6,000' feet downstream of the Daly West Mine dump. The area between the two features continues to show elevated levels of metals (*See*, Section 3.0).

2.3 Empire Canyon Trail Sampling

In November 2001, soil samples were collected along recreational trails located in Empire Canyon. A total of 15 samples were collected to assess the concentrations of metals located in recreational use areas (*See*, Figure 2). Samples were collected in areas where trails cross the Judge Mine, Daly West and Alliance mine dumps. Samples were also collected in non-impacted areas to assess background conditions. Analytical sample results are presented in Table 7. Soil data collected indicate that lead ranges from 229 to 18,540 ppm, and arsenic ranges from 23 to 349 ppm. Laboratory reports are included in Appendix 2.

2.4 Other Investigations

Analytical soil results from sampling events conducted by RMC and UPCM in 1999 and 2000 are presented in Table 8. The soil samples were collected in the lower reach of the canyon from the Judge Mine tunnel downstream to below the iron gate in and near the stream channel (*See*, Figure 2). The soil samples were collected as part of the initial assessment and scoping activities at the Site.

Soil data collected indicate that arsenic, barium, chromium, lead, and zinc concentrations were elevated when compared to typical soil levels. Arsenic ranged from 64 to 181 ppm, barium ranged from 147 to 2,210 ppm, chromium ranged from 75 to 322 ppm, lead ranged from 1,200 to10,190 ppm and zinc ranged from 1,800 to 14,990 in the lower reach of the canyon. Analytical surface water results from sampling events conducted by RMC and UPCM in 1999 and 2000 are presented in Table 9. These sample events were conducted as part of the initial assessment and scoping activities at the Site. The surface water samples were collected from the lower reach of the Empire Canyon upstream to below the Daly West Mine dump and from the confluence of Walker Webster with Empire Canyon upstream to the Keystone Mine in Walker Webster Gulch *(See*, Figure 3).

The 1999 sediment data show a positive correlation between high metal concentrations in soils with elevated surface water metal concentrations. As discussed above all of the sediment data collected in 1999 was limited to the Judge Mine tunnel area and downstream to below the Iron Gate. Surface water data from 1999 indicate that most of the metal is found in the dissolved phase. With the exception of one (1) sample collected near the Iron Gate (UP-W-1) total and dissolved arsenic concentrations were below the detection limit of 0.02 ppm. The field pH for UP-W-1 was measured at 2.9 s.u. all measured metal concentrations were elevated in this sample as can be expected with a low pH. UP-W-2 collected approximately 200' upstream on the same day had a near neutral pH of 6.8 and zinc was the only elevated metal measured at this sample location. Subsequent sampling at the Iron Gate over the next 3 years has not revealed a similar low pH or extremely elevated metal concentrations. Cadmium was found at concentrations that exceed surface water quality standards for Silver Creek, dissolved cadmium ranged from <0.005 to 0.14 ppm and was found at high concentrations in areas where visible tailings deposits are present in the channel (e.g., Walker Webster flume, Iron Gate flume areas). Total zinc ranged from to 0.03 to 28 ppm and dissolved zinc ranged from 0.023 to 27 ppm. The extremely high metal concentrations were measured at UP-W-1.

3.0 2002 SAMPLING

Surface water sampling was conducted by RMC and UPCM personnel during the spring of 2002. The sampling was conducted to assess current conditions at the Site. A total of twenty-five (25) samples were collected at twenty-three (23) locations. Analytical results are presented in Table 10, sample locations are shown Figure 4. Laboratory reports are included in Appendix 2. Total aluminum concentrations ranged from <0.05 to 68 ppm, dissolved aluminum ranged from <0.05 to 0.071 ppm, very little of the aluminum is present in the dissolved phase. The sample location above the Daly West Mine waste rock area (ECA-SW-05) and the culvert outfall below the Daly West (ECA-SW-06) contained most of the native soil elements such as iron and aluminum.

These samples were also extremely turbid and likely represent typical non-impacted by mining activity spring runoff water quality. Dissolved metals associated with mine wastes (e.g., zinc, cadmium, lead and arsenic) were detected at low concentrations at these sample locations.

Arsenic was detected in the total metal phase at concentrations ranging from 0.31 to <0.005 ppm, dissolved arsenic concentrations were mostly below the detection limit of 0.005 ppm with a few locations containing dissolved arsenic just above the detection limit at 0.006 ppm. Copper was present in the total phase at concentrations ranging from 0.013 to 0.7 ppm, and dissolved copper concentrations ranged from 0.042 to <0.005 ppm. Total zinc concentrations ranged from 0.86 ppm to 6.9 ppm. Dissolved zinc concentrations ranged from below laboratory detection limits <0.010 ppm to 6.7 ppm. Total cadmium ranged from 0.037 to 0.004 ppm, dissolved cadmium concentrations ranged from <0.001 to 0.036 ppm. The highest concentration of cadmium was detected approximately 1,000 feet downstream of the Daly West Mine waste rock pile.

The highest concentrations of zinc in surface water was observed in the samples collected from the Walker-Webster Gulch flume and the reach of Empire Canyon located below the Daly West mine dump and the Judge Tunnel. The samples collected from waters emanating from the diversion culvert at the Daly West mine dump (ECA-SW- 05, Table 10, Figure 4) do not contain elevated concentrations of dissolved metals.

DRAFT

4.0 SITE CHARACTERIZATION

This section provides information on the extents of metals in soil, sediment and water at the Site.

Concentrations of metals in soils are highly variable throughout the Site. This is primarily due to two factors: 1) the variable nature of soils and 2) sampling bias; samples are typically collected in areas suspected of being background and/or impacted. In general high concentrations of metals in soils are limited to areas that have been disturbed by mining related activities.

Surface water flow in Empire Canyon occurs during the spring runoff cycle which typically occurs from late April through early June. Peak flow in Lower Empire Canyon Measured in May 2001 was 6.29 cubic feet per second. Additional localized flows may occur in response to sporadic short-duration summer storm events. Flow from these sporadic events are limited in duration and do not contribute significantly to the local hydrologic regime.

Results of water and sediment sampling indicate that elevated concentrations of metals in water and sediment can be roughly correlated, that is channel reaches containing elevated concentrations of metals in sediments may contain surface water with elevated concentrations of metals. However, there are areas within the Site where stream sediments contain moderate metal concentrations and surface waters contain elevated metal concentrations.

Based on the results of the 2002 sampling zinc loading is currently occurring in areas where surface and near-surface waters are in contact with tailings. In 2001 storm drain culverts were installed upstream of the Daly-West waste rock pile. The culverts collect surface drainage coming down from the Anchor-Judge mine area and from the Empire Lodge area. The culvert exits at the downstream toe of the Daly West pile. Data collected from this culvert in 2002 showed dissolved zinc concentrations at <0.01 mg/l, data collected prior to the culvert installation showed, in 1999 that dissolved zinc concentrations were 3.4 mg/l. Additional culverts are being placed on the upstream portion of the Daly West area to collect additional surface water flows. Elevated concentrations of zinc observed in the reach below the Daly West mine dump may be attributed to snowmelt waters seeping into the ground above the Daly West and then emanating as surface water below the Daly West. Samples collected at ECA-SW-7 through ECA-SW-11 show elevated metals concentrations with most of the metal found in the dissolved phase. In 1997 United Park remediated the Empire Canyon channel from just below the Daly West Mine area to just above the Judge Mine tunnel. Tailings were removed from the channel and a new channel was constructed with clean material. Therefore it seems plausible that the high metal concentrations found in the surface waters in this section of the canyon are related to mine wastes located in the Daly West waste rock pile.

Development activities in the 2002 construction season near the Site will likely reduce the amount of mine by-products available for interaction with surface waters. As mentioned above the Daly West surface drainage system will continue to be improved resulting in less upstream water coming into contact with the waste rock pile.

The lower section of the canyon, defined as from the Judge Mine tunnel downstream to the sediment pond located below the Iron Gate, contains tailings and some mine rock in direct contact with the runoff waters. Water quality is directly affected by the mine wastes in this area. The confluence area of the Walker-Webster Gulch with Empire Canyon also contains tailings in direct contact with surface waters. Water quality near the Walker-Webster flume indicates that zinc, cadmium, antimony and lead exceed water quality standards for the downstream Silver Creek.

Surface water samples collected in the previously remediated reach of Walker-Webster Gulch contain slightly elevated concentrations of zinc. Dissolved zinc concentrations range from 0.046 to 0.76 ppm.

During the 2002 sampling the Park City Municipal Corporation (PCMC) water tank overflow was sampled. On May 6, 2002 during the Site Characterization sampling the tank was overflowing into the Empire Channel water quality samples were collected and submitted for analyses. The data are presented in Table 10 and indicate that zinc exceeds applicable water quality standards for Silver Creek downstream of Empire Canyon.

5.0 REFERENCES

Resource Management Consultants (RMC), 2001a, Empire Canyon Trail Sampling Results.

Resource Management Consultants (RMC), 2001b, Results of Sampling Activities, Flagstaff Development.

Upper Silver Creek Watershed Group (USCWG) 2000, Analytical Results For Surface Water and Sediment Monitoring Activities Conducted May 2000, Addendum to The Sampling and analysis Plan For Upper Silver Creek Watershed.

Upper Silver Creek Watershed Group (USCWG) 2001, Analytical Results For Surface Water and Sediment Monitoring Activities Conducted September and November 2000, Addendum to The Sampling and analysis Plan For Upper Silver Creek Watershed.

Utah Department of Environmental Quality, Division of Environmental Response and Remediation (DERR), 2001, Expanded Site Inspection Workplan, Empire Canyon, Summit County, Utah, UT0002005981.

Utah Department of Environmental Quality, Division of Environmental Response and Remediation (DERR), 2001b, Tracer Study Results Report, Empire Canyon, Summit County, Utah, UT0002005981.

Tabbed Page: Figures

Color Map(s)

The following pages contain color that does not appear in the scanned images.

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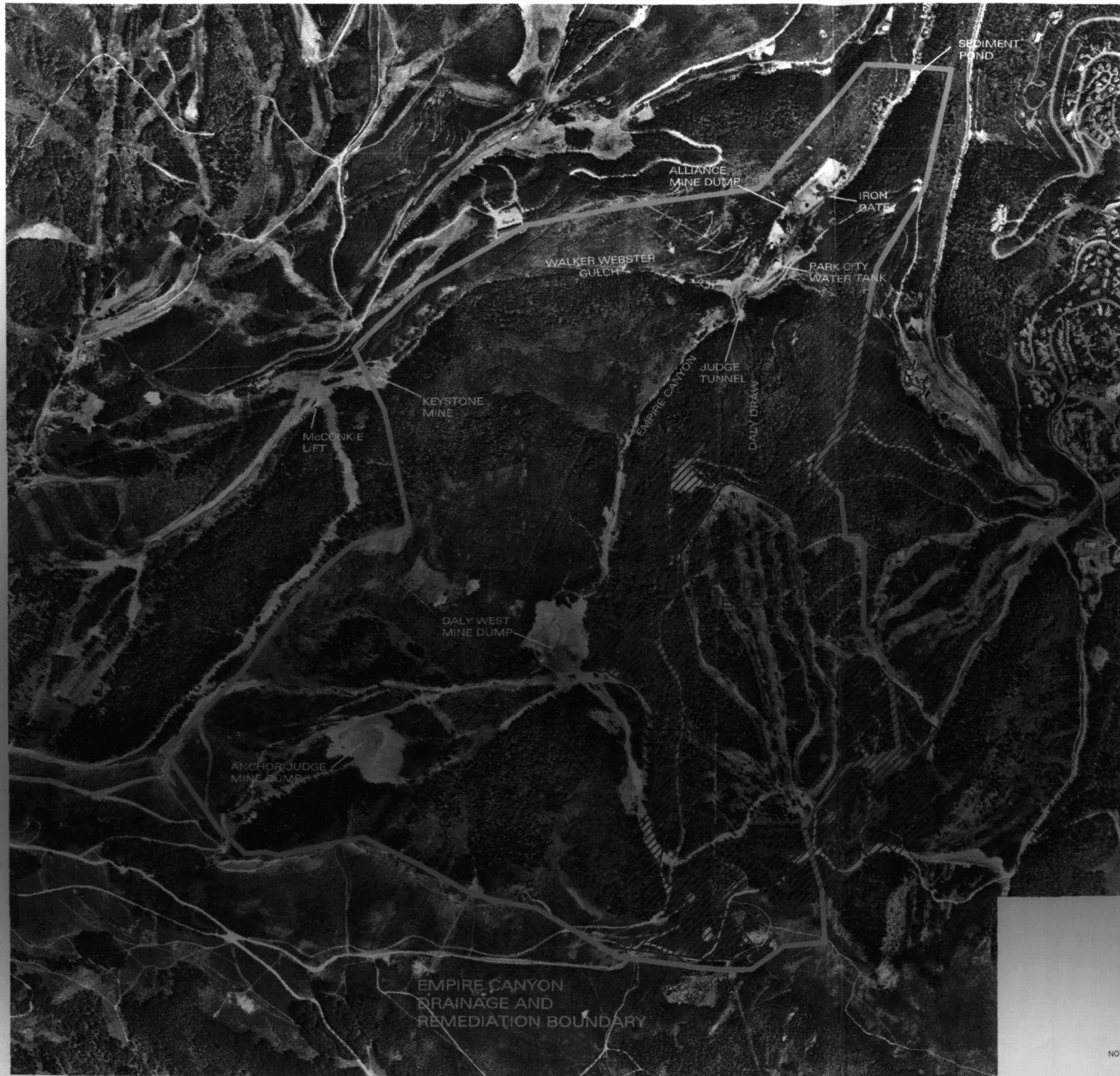


NOT TO SCALE

N

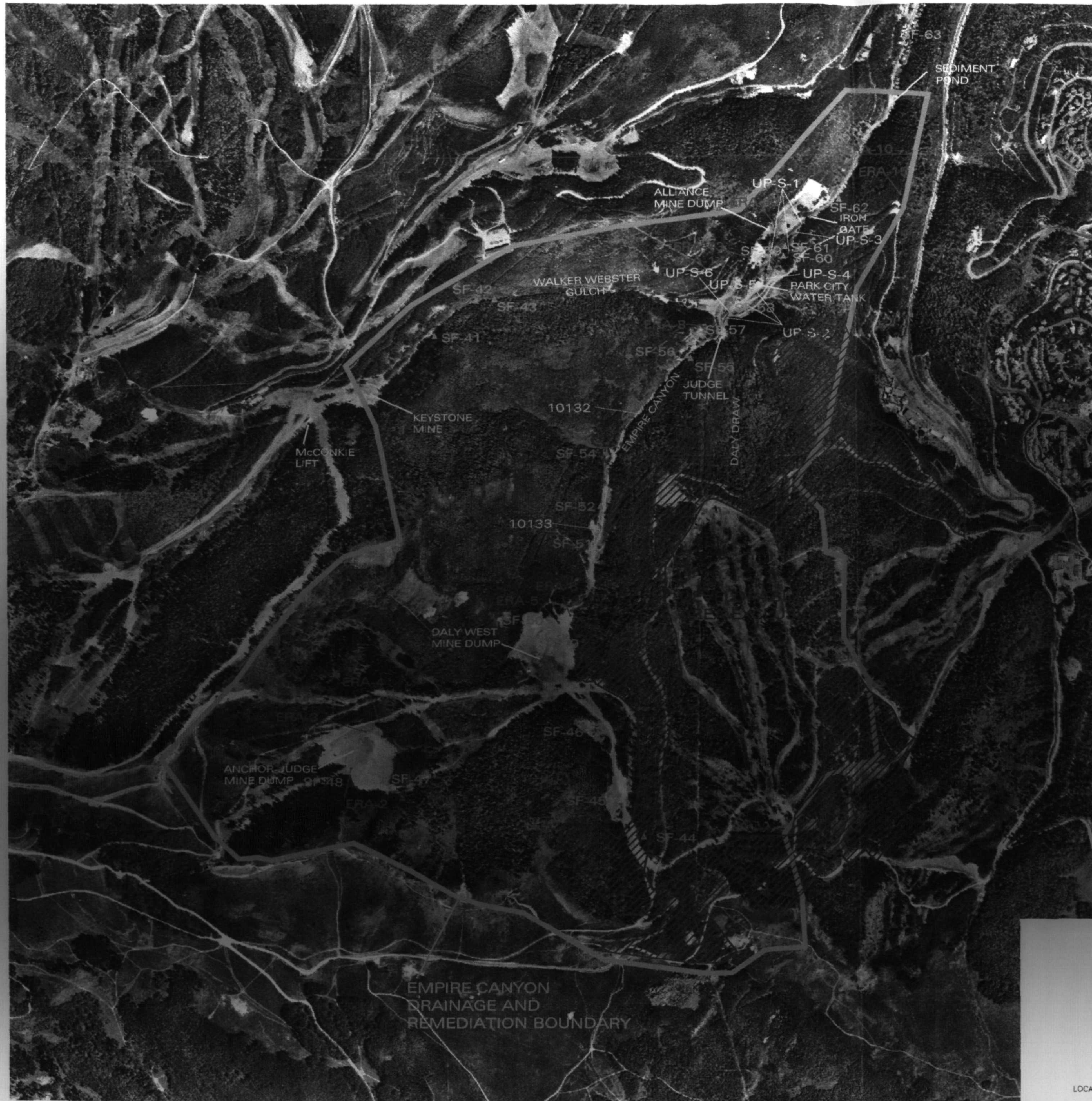
UNITED PARK CITY MINES

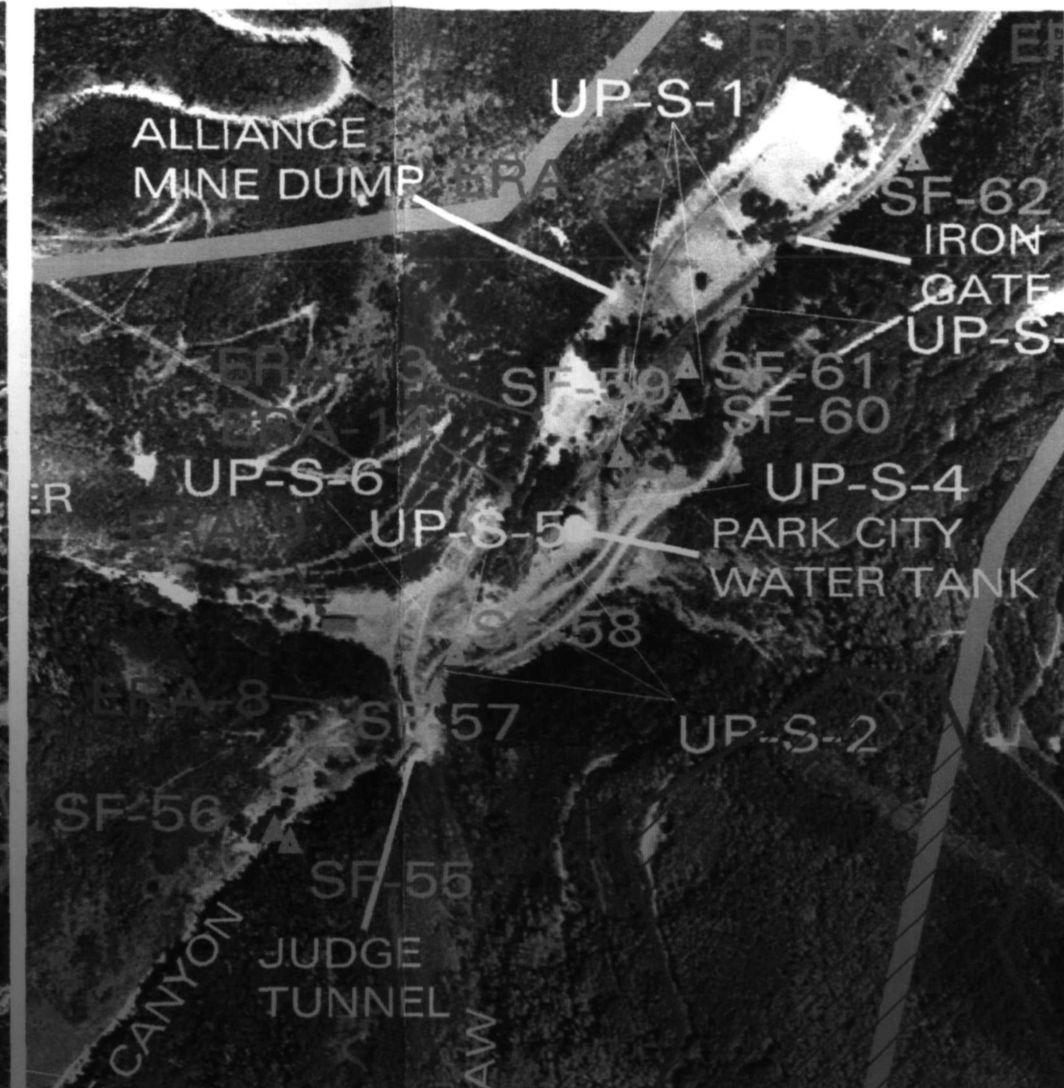
FIGURE 1
EMPIRE CANYON SITE MAP

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

JULY 2002

GEOREF-AERIAL-3





• ERA-10	EMPIRE TRAIL SAMPLING (2001)
▲ SF-62	DERR SOIL SAMPLE (2001)
— UP-S-1	RMC/UPCM SAMPLE (1999) (YELLOW)

NOT TO SCALE
LOCATIONS APPROXIMATE – NOT SURVEYED

N

UNITED PARK CITY MINES

FIGURE 2
EMPIRE CANYON
SOIL SAMPLE LOCATIONS

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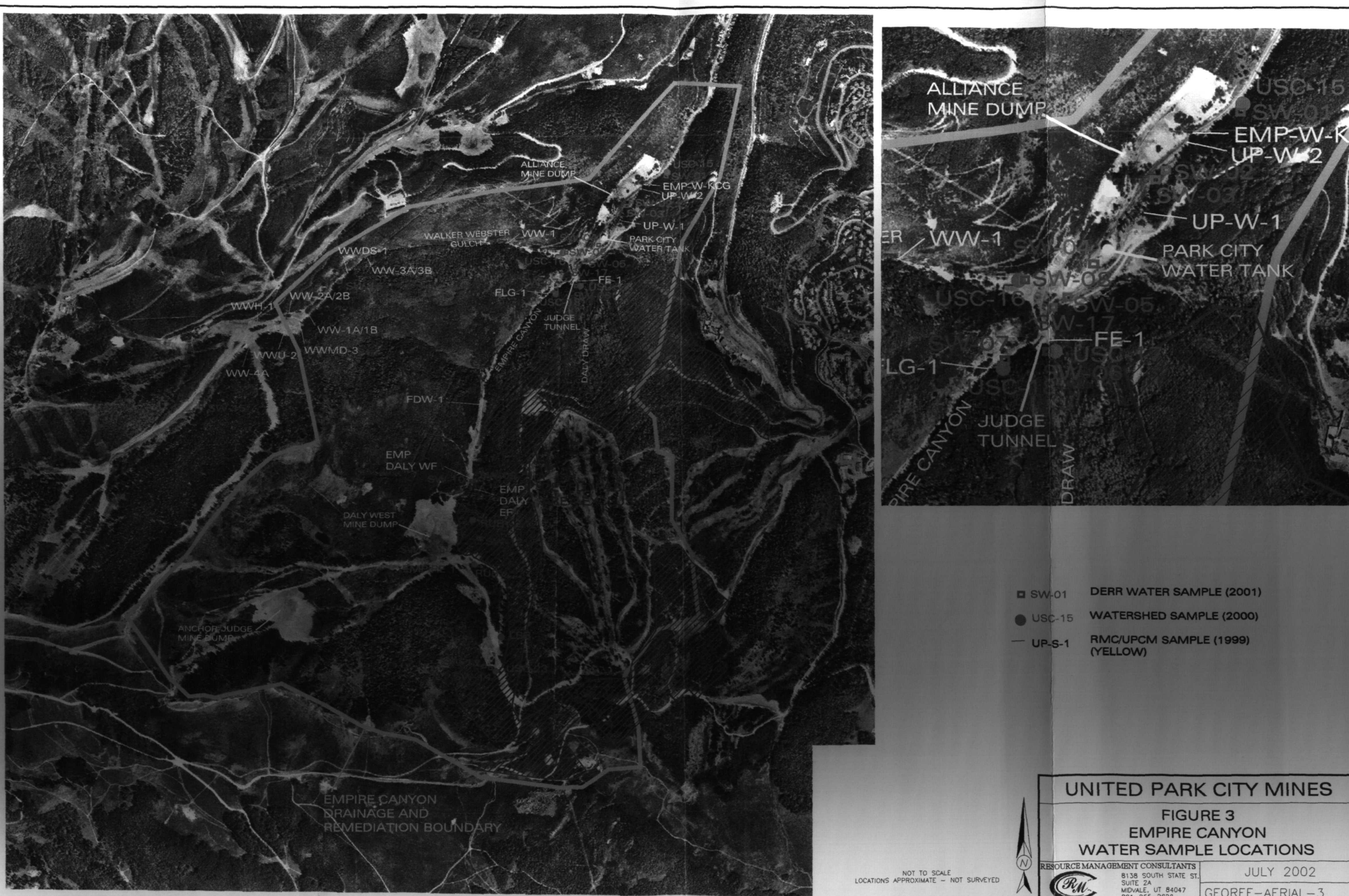
SUITE 2A
MIDVALE, UT 84047
801-255-2626

JULY 2002

GEOREF-AERIAL-3



UNITED PARK CITY MINES

FIGURE 3
EMPIRE CANYON
WATER SAMPLE LOCATIONS

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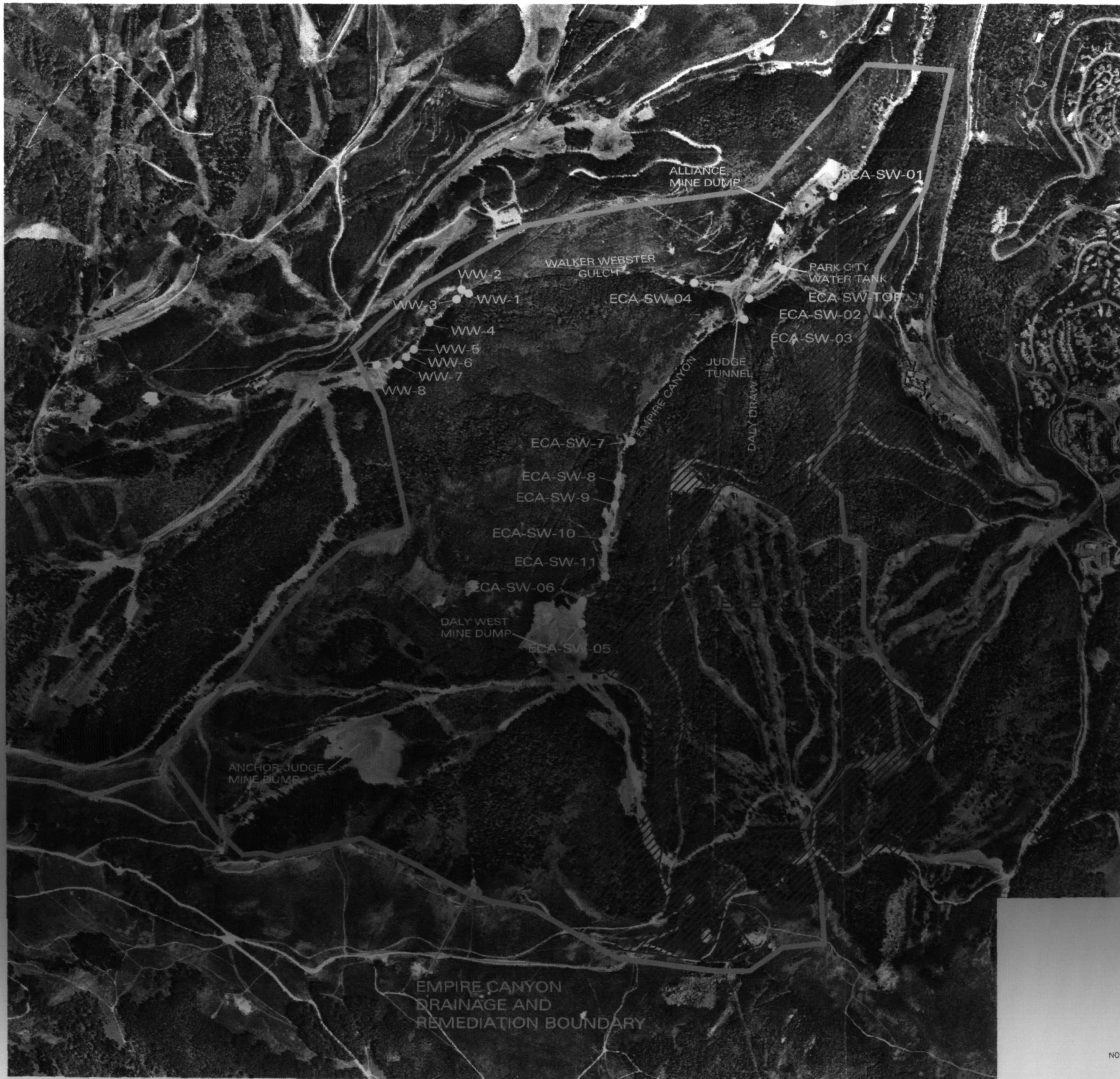
801-255-2626

JULY 2002

GEOREF-AERIAL-3



LEGEND

SURFACE WATER
SAMPLE LOCATION

NOT TO SCALE

N

UNITED PARK CITY MINES

FIGURE 4
EMPIRE CANYON
2002 SAMPLE LOCATION MAP

RESOURCE MANAGEMENT CONSULTANTS
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SUITE 2A
MIDVALE, UT 84047
801-255-2626

JULY 2002

GEOREF-AERIAL-3

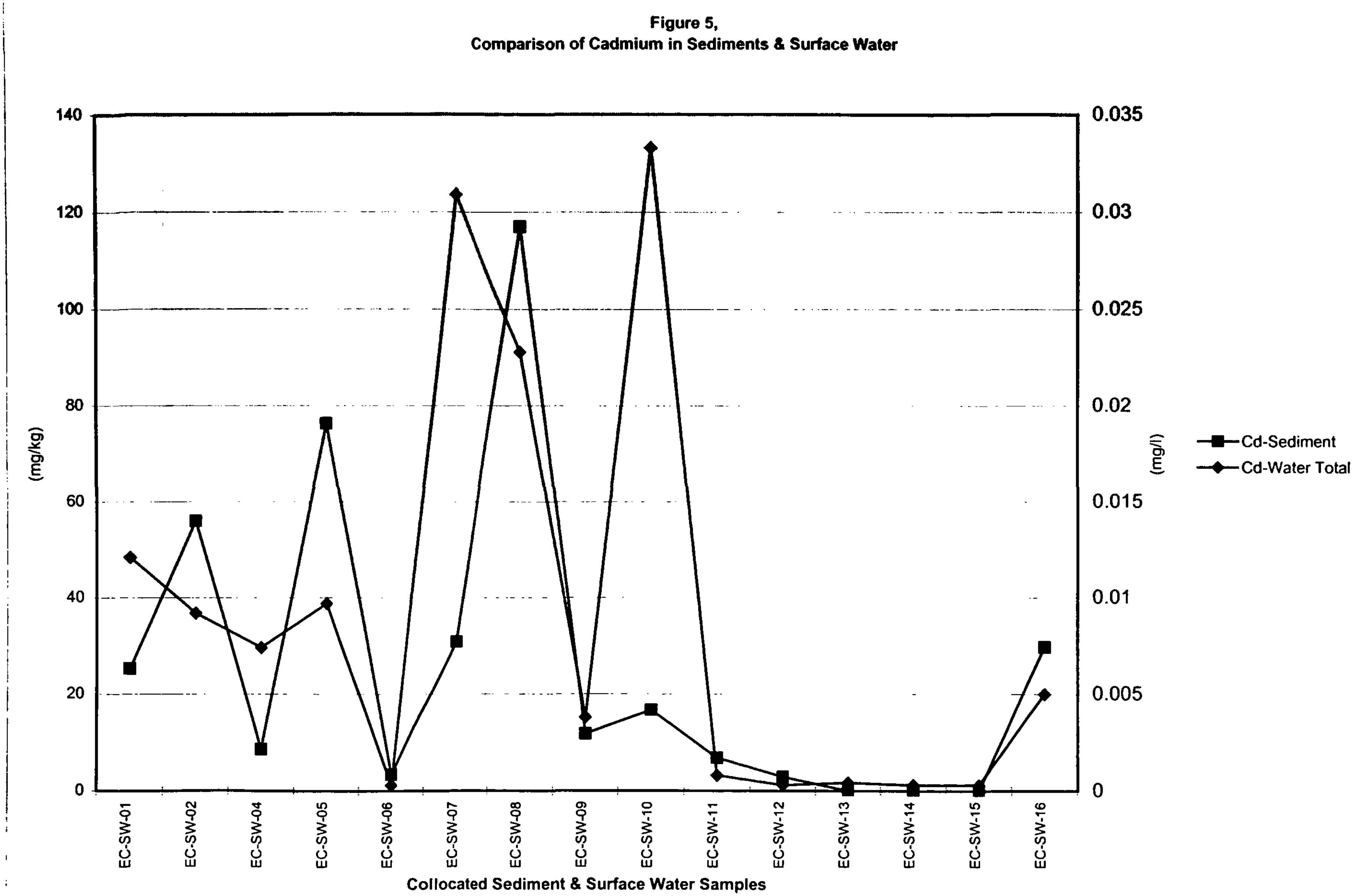
Figure 5,
Comparison of Cadmium in Sediments & Surface Water
140
120
100
80
60
40
20
0
(mg/kg)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
(mg/l)
Cd-Sediment
Cd-Water Total
EC-SW-01
EC-SW-02
EC-SW-04
EC-SW-05
EC-SW-06
EC-SW-07
EC-SW-08
EC-SW-09
EC-SW-10
EC-SW-11
EC-SW-12
EC-SW-13
EC-SW-14
EC-SW-15
EC-SW-16
Collocated Sediment & Surface Water Samples

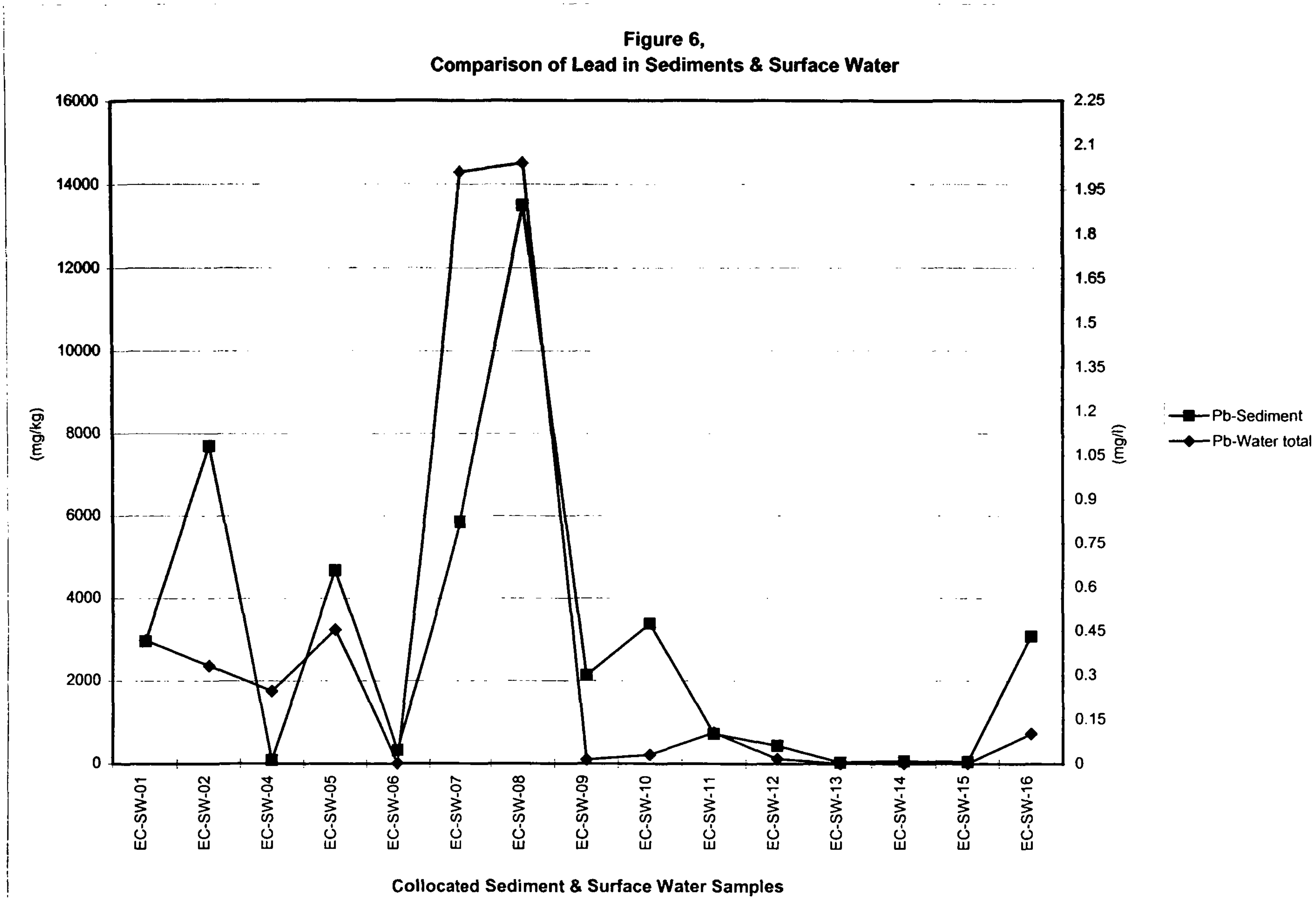
Figure 6,
Comparison of Lead in Sediments & Surface Water
16000
14000
12000
10000
8000
6000
4000
2000
0
(mg/kg)
2.25
2.1
1.95
1.8
1.65
1.5
1.35
1.2
1.05
0.9
0.75
0.6
0.45
0.3
0.15
0
(mg/l)
Pb-Sediment
Pb-Water total
EC-SW-01
EC-SW-02
EC-SW-04
EC-SW-05
EC-SW-06
EC-SW-07
EC-SW-08
EC-SW-09
EC-SW-10
EC-SW-11
EC-SW-12
EC-SW-13
EC-SW-14
EC-SW-15
EC-SW-16
Collocated Sediment & Surface Water Samples

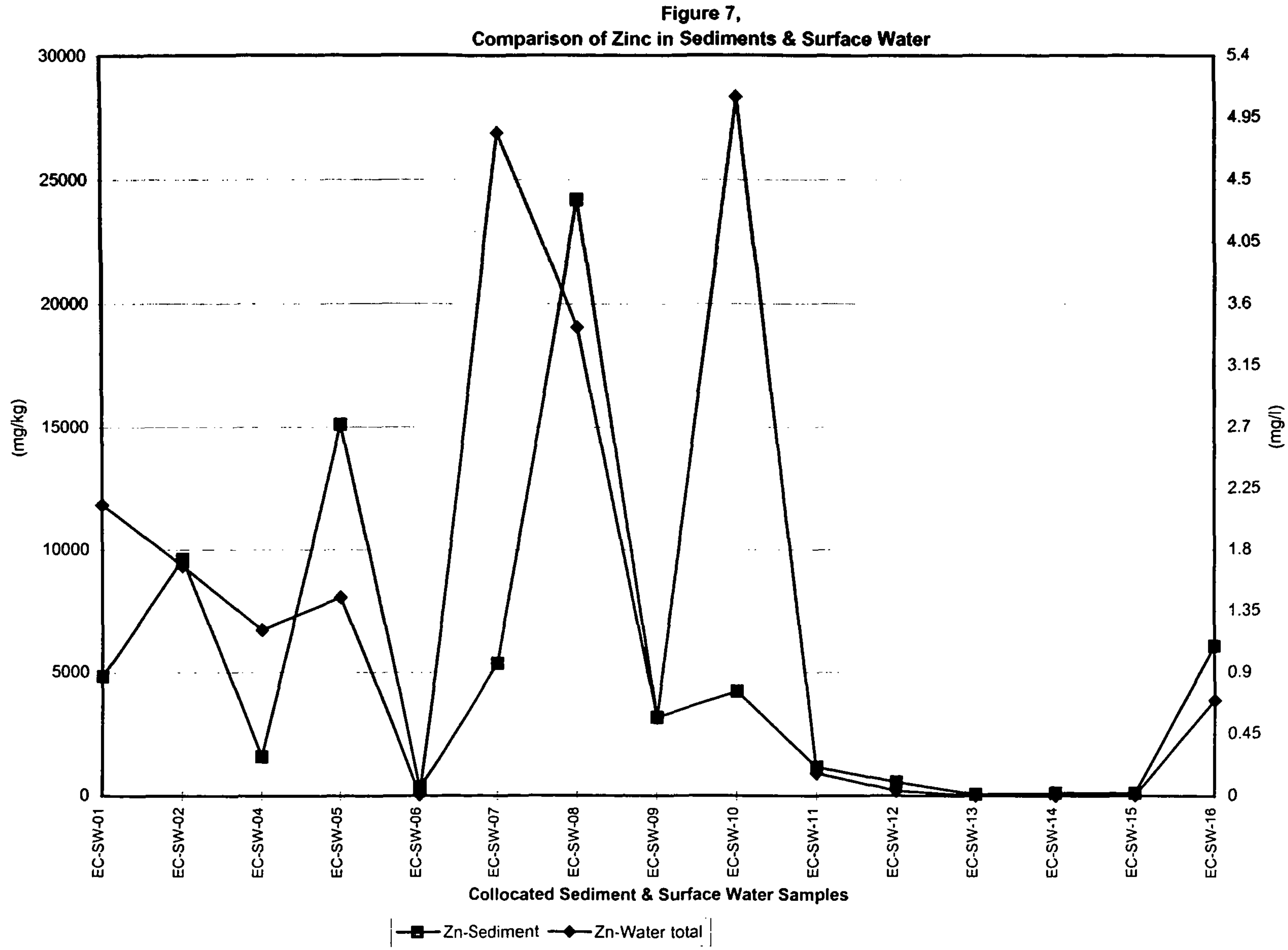
Figure 7,
Comparison of Zinc in Sediments & Surface Water
30000
25000
20000
15000
10000
5000
0
(mg/kg)
5.4
4.95
4.5
4.05
3.6
3.15
2.7
2.25
1.8
1.35
0.9
0.45
0
(mg/l)
EC-SW-01
EC-SW-02
EC-SW-04
EC-SW-05
EC-SW-06
EC-SW-07
EC-SW-08
EC-SW-09
EC-SW-10
EC-SW-11
EC-SW-12
EC-SW-13
EC-SW-14
EC-SW-15
EC-SW-16
Collocated Sediment & Surface Water Samples
Zn-Sediment
Zn-Water total

Tabbed Page: Tables

Table 1, Upper Silver Creek Watershed,
Empire Canyon Sample Locations,
Analytical Results Summary, May 2000

units ppm except for Hg - ppb

Date	Sample #	Description	AG	AG(D)	AL	AL(D)	AS	AS(D)	CA	CD	CD(D)	CU	CU(D)	FE	FE(D)	HG ppb	HG (D) ppb	HARD	MG	MN	MN(D)	PB	PB(D)	PH	SB	SB(D)	SE	SE(D)	TDS	TSS	ZN	ZN(D)
16-May-00	USC-11	EMP.Cyn.@CULVERT	<0.005	<0.005	0.22	<0.050	<0.005	<0.005	83	<0.001	<0.001	<0.005	<0.005	0.32	<0.10			288	19	0 18	0.17	<0.005	<0.005	8.3	<0.005	<0.005	<0.005	<0.005	646	9 5	0 15	0.1
16-May-00	USC-13	EMP.Cyn@flow drain	<0.005	<0.005	0.06	<0.050	<0.005	<0.005	98	0.044	0.044	0.01	0.007	<0.10	<0.10			287	10	0 036	0.039	0.052	0.021	7.6	0.028	0.028	0.008	0.009	548	<1.0	5.3	5 3
16-May-00	USC-15	Flume.EMP.Cyn iron gate	<0.005	<0.005	<0.050	<0.050	<0.005	0.005	72	0.027	0.029	0.006	0.005	<0.10	<0.10	4.82	2.87	210	7.1	<0.010	<0.010	0.028	0.024	7.5	0.03	0.03	0 005	0 008	299	<1.0	4.3	4.4
16-May-00	USC-17	Abv flume.adj.JudgeTunnel	<0.005	<0.005	<0.050	<0.050	<0.005	<0.005	31	<0.001	<0.001	<0.005	<0.001	<0.10	<0.10			106	6.9	<0.010	<0.010	<0.005	<0.005	7.3	<0.005	<0.005	<0 005	<0 005	151	<1.0	0.011	0 011
16-May-00	Empire 1	Upper Empire Canyon								0.022	<0.003											0.062	<0.005								0 17	0 078
16-May-00	Ruby 1	Ruby Chairlift								0.046	<0.003											0.012	<0.005								0.091	0.049
16-May-00	Ruby-2	Gulch North of Daly West								0.002	0.002											0.006	<0.005								0 1	0 13
31-May-00	LBA	LittleBell Above							5.7	<.003	<.003			.063	.030			21.	1.7	<.010	<.010	<.010	<.010	6.9					45.	2.2	.045	.027
31-May-00	LBB	Littlebell Below							8.5	<.003	<.003			.39	.031			33.	2.8	<.010	<.010	<.010	<.010	6.9					55.	2.2	.071	.065

Table 2, Upper Silver Creek Watershed, Empire Canyon Sediment Samples

units ppm

Date	Sample #	Description	AG	AL	AS	CD	CR	CU	FE	HG	PB	SB	SE	ZN
		SEDIMENT												
28-Sep-00	CYN.FLUME (USC-15)	SURFACE	138	11310	513	60	40	1540	33600	0.56	12310	258	<5.0	10960
28-Sep-00	GULCHFLUME (W.W.)	SURFACE	28	10540	78	60	17	343	32310	<0.1	17120	95	5.2	11680
28-Sep-00	DAILYFLUME (USC-17)	SURFACE	55	8067	187	57	26	569	29290	0.46	9025	84	<5.0	9838

Table 3, DERR Sample Results
Empire Canyon - 2001 Surface Water

units ppm

Station Location	Location Description	Analysis	AL	SB	AS	BA	BE	CD	CA	CR	CO	CU	FE	PB	MG	MN	HG	NI	K	SE	AG	NA	TL	V	ZN	CN
EC-SW-01	Lower Empire Canyon just above sediment pond	Total	0.687	0.0214	0.0159	0.0458	0.0002	0.0121	59.8	0.0017	0.0011	0.0312	1.14	0.419	8.26	0.0969	0.0001	0.0015	1.59J	0.0049	0.0019	4.77J	0.0039	0.0015	2.13	NR
EC-SW-02	Iron gate flume	Total	0.591	0.0164	0.0106	0.0425	0.0002	0.0092	57	0.0013	0.0011	0.0249	0.926	0.332	7.92	0.0922	0.0001	0.0018	1.49J	0.0034	0.0011	4.35J	0.0039	0.0013	1.68	NR
EC-SW-03	Seep on west side of canyon at Iron Gate	Total	0.168	0.0163	0.004	0.0427	0.0002	0.0377	93.6	0.0007	0.0011	0.0026	0.183	0.0134	10.9	0.0086	0.0001UJ	0.0037	2.09J	0.0074	0.0008	7.88J	0.0039	0.0009	8.87	NR
EC-SW-04	Empire channel below Park City turbidity turnout.	Total	0.63	0.0141	0.0082	0.0421	0.0002	0.0074	55.3	0.0001	0.00011	0.00186	0.82	0.246	8	0.0471	0.0001	0.0015	1.46J	0.0034	0.00086	4.34J	0.0039	0.0011	1.21	NR
EC-SW-05	Empire channel above Park City turbidity turnout, below confluence of Walker Webster and Daly Draw.	Total	0.704	0.0178	0.004	0.0549	0.0002	0.0097	46.9	0.0016	0.0011	0.0195	0.793	0.455	6.98	0.0656	0.0001	0.0015	1.44J	0.0034	0.0012	4.36J	0.0039	0.0014	1.45	NR
EC-SW-06	Daly Draw above flume	Total	0.168	0.003	0.004	0.0425	0.0002	0.0003	27.6	0.0007	0.0011	0.0013	0.0681	.0015U	6.27	0.0044	0.0001UJ	0.0015	1.14J	0.00345	0.0008	4.45J	0.0039	0.0009	0.0087	NR
EC-SW-07	Empire Flume above Judge portal	Total	2.65	0.111	0.0861	0.0904	0.0002	0.0309	57.7	0.0069	0.0019	0.225	4.98	2.01	8.15	0.584	0.0004	0.0038	2J	0.0034	0.00229	3.13J	0.0039	0.0057	4.84	NR
EC-SW-07	Empire Flume above Judge portal	Dissolve	0.168	0.0251	0.0044	0.0414	0.0002	0.0178	50.5	0.0007	0.0011	0.0077	0.0546	0.0137	5.67U	0.0022	0.0001	0.0015	1.46J	0.0034	0.0008	3.05J	0.0039	0.0009	2.35	NR
EC-SW-08	Walker Webster flume	Total	0.826	0.0315	0.0136	0.0582	0.0002	0.0228	77.5	0.0018	0.0011	0.0435	1.18	2.04	8.59	0.146	0.0001	0.0015	1.48J	0.0034	0.0027	3.25J	0.0039	0.0018	3.43	NR
EC-SW-09	Little Bell drainage (east fork of Empire) above upper confluence	Total	0.168	0.0057	0.004	0.0972	0.0002	0.0038	64.2	0.0007	0.0011	0.0038	0.0546	0.0138	9.08	0.0368	0.0001	0.0015	1.19J	0.0034	0.0008	4.45J	0.0039	0.0009	0.569	NR
EC-SW-10	Empire drainage (west fork) below Daly West above confluence with east fork	Total	0.168	0.516	0.0087	0.0628	0.0002	0.0333	162	0.0007	0.0011	0.0097	0.0547	0.0305	14.2	0.0054	0.0001	0.0015	2.13J	0.0053	0.0008	6.31J	0.0039	0.0009	5.1	NR
EC-SW-11	Empire Canyon at Empire Chairlift	Total	1.58	0.0109	0.0095	0.0189	0.0002	0.0008	8.09	0.0022	0.0011	0.0193	1.54	0.105	1.46	0.205	0.0001	0.0015	0.956J	0.0034	0.0014	0.857J	0.0039	0.0026	0.162	NR
EC-SW-12	Empire Canyon at Ruby Chairlift	Total	0.495	0.003	0.004	0.0171	0.0002	0.0003	7.54	0.0007	0.0011	0.0049	0.428	0.0167	1.3	0.296	0.0001	0.0015	1.39J	0.0034	0.0008	0.995J	0.0039	0.0009	0.0355	NR
EC-SW-13	Above Little Bell Mine	Total	0.311	0.0038	0.0021	0.0539	0.0004	0.00043	4.49	0.001	0.0021	0.0009	0.166	0.0009	1.38	0.0036	0.0001	0.0018	0.316	0.0023	0.00075	3.14	0.0035	0.0027	0.001	
EC-SW-14	Above Little Bell Mine (spring?)	Total	0.391	0.0016	0.0021	0.0321	0.0004	0.0003	4.2	0.0008	0.0003	0.0009	0.177	0.0009	1.22	0.0031	0.0001	0.0007	0.19	0.0023	0.0007	2.61	0.0035	0.0006	0.0001	
EC-SW-15	Above Walker-Webster mine site	Total	0.0391	0.0016	0.0021	0.0164	0.0004	0.0003	38	0.0007	0.0003	0.0009	0.0124	0.0009	4.86	0.00015	0.0001	0.0007	0.413	0.0023	0.0007	2.95	0.0035	0.0007	0.0039	
EC-SW-16	Below Walker-Webster mine site	Total	0.198	0.006	0.0021	0.0363	0.0004	0.005	59.4	0.0009	0.00032	0.0035	0.211	0.102	6.62	0.0141	0.0001	0.0007	0.851	0.0023	0.00071	2.72	0.0035	0.0008	0.697	
EC-SW-17	Daly salt tracer outflow	Total	0.221	0.0087	0.0064	0.0308	0.0002	0.0052	33.3	0.0008	0.0011	0.0057	0.164	0.0226	5.57	0.0091	0.0001UJ	0.0015	1.34J	0.0034	0.0008	13.9J	0.0039	0.0009	1.02	NR
EC-SW-18	Judge tunnel at turnout during turnout study	Total	0.0436	0.0116	0.006	0.0075	0.0004	0.0025	63.6	0.0143	0.0007	0.0167	0.306	0.0098	8.74	0.0132	0.0001	0.007	1.21	0.0041	0.0005	4.17	0.0041	0.0008	0.824	
EC-SW-18	Judge tunnel at turnout during turnout study	Dissolve	0.0436	0.0076	0.0012	0.0063	0.0004	0.0021	60.8	0.001	0.0007	0.0067	0.0106	0.0018	8.36	0.008	0.0001	0.0014	1.16	0.0028	0.0005	4.05	0.0041	0.0006	0.604	
EC-SW-19	Judge tunnel at downgradient flume during turnout study	Total	0.0553	0.0139	0.004	0.0118	0.0004	0.0037	60	0.0098	0.0011	0.0113	0.198	0.0175	8.15	0.008	0.0001	0.0056	1.14	0.0028	0.0005	3.8	0.0041	0.0013	0.897	
EC-SW-19	Judge tunnel at downgradient flume during turnout study	Dissolve	0.0436	0.0114	0.0029	0.0116	0.0004	0.0035	63.2	0.003	0.0007	0.0059	0.0106	0.0018	8.63	0.0031	0.0001	0.0027	1.24	0.0049	0.00074	4.36	0.0041	0.001	0.582	
EC-SW-20	Judge tunnel water, down gradient at sed pond during turnout study	Total	0.114	0.0134	0.0045	0.0125	0.0004	0.0067	61.7	0.001	0.0007	0.0087	0.179	0.0384	8.33	0.0098	0.0001	0.0014	1.22	0.0028	0.00059	4.04	0.0041	0.0007	1.22	
EC-SW-20	Judge tunnel water, down gradient at sed pond during turnout study	Dissolve	0.0492	0.015	0.0025	0.0117	0.0004	0.0061	62.3	0.001	0.0007	0.0024	0.0106	0.004	8.36	0.00051	0.0001	0.0014	1.22	0.0042	0.00066	4.18	0.0041	0.0006	0.685	
EC-SW-22	Duplicate of EC-SW-08	Total	0.76	0.025	0.0077	0.0513	0.0002	0.0209	73.6	0.0012	0.0011	0.034	0.928	1.36	8.22	0.0976	0.0001	0.0015	1.44J	0.0034	0.002	3.17J	0.0039	0.0014	3.07	NR
EC-SW-23	Duplicate of EC-SW-16	Total	0.112	0.0047	0.0021	0.0363	0.0004	0.0051	60.4	0.0008	0.00032	0.002	0.0742	0.0518	6.7	0.0085	0.0001	0.0008	0.817	0.0023	0.0007	2.79	0.0035	0.0008	0.663	

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BE, CD, and TL "U" = BLANK CONTAMINATION
NA "UJ" AND "U" = NEGATIVE BLANK CONTAMINATION
CU and K "J" = SERIAL DILUTION % GREATER THAN 10% AND ORIGIONAL SAMPLE VALUE AT LEAST 50 IDL (Instrument Detection Limit)
SB, AG, AND CU "JJ" = MATRIX SPIKE RECOVERY EXCEED QC LIMITS

Table 4, DERR Empire Canyon 2001 Flow Data

DATE	FLUME LOCATION	FLUME MEASUREMENT	ft3/sec	GPM	NOTES
23-Apr	DD	Dry	ND	ND	Daly Draw Flume
30-Apr	DD	Dry	ND	ND	Daly Draw Flume
30-Apr	DD	0.16	0.11	49.37	Daly Draw Flume
7-May	DD	Dry	ND	ND	Daly Draw Flume
9-May	DD	0.31	0.32	143.62	Daly Draw Flume
9-May	DD	0.47	0.62	278.26	Daly Draw Flume
9-May	DD	0.61	0.94	421.87	Daly Draw Flume
10-May	DD	0.62	0.97	435.34	Daly Draw Flume
10-May	DD	0.71	1.2	538.56	Daly Draw Flume
14-May	DD	0.9	1.74	780.91	Daly Draw Flume, Sample EC-SW-06
24-May	DD	0.38	0.45	201.96	Daly Draw Flume
11-Jun	DD	Dry	ND	ND	Daly Draw Flume
7-May	EC	Dry	ND	ND	Middle Empire Canyon Flume
9-May	EC	Dry	ND	ND	Middle Empire Canyon Flume
9-May	EC	0.32	0.54	242.35	Middle Empire Canyon Flume
9-May	EC	0.13	0.16	71.81	Middle Empire Canyon Flume, Sample EC-SW-07
10-May	EC	0.21	0.28	125.66	Middle Empire Canyon Flume
14-May	EC	0.37	0.67	300.02	Middle Empire Canyon Flume
24-May	EC	Dry	ND	ND	Middle Empire Canyon Flume
11-Jun	EC	Dry	ND	ND	Middle Empire Canyon Flume
20-Apr	IG	0.13	<0.33 *	<146.3 *	Empire Canyon Iron Gate Flume
23-Apr	IG	0.1	<0.33 *	<146.3 *	Empire Canyon Iron Gate Flume
30-Apr	IG	0.27	0.52	233.38	Empire Canyon Iron Gate Flume
7-May	IG	0.52	1.43	641.78	Empire Canyon Iron Gate Flume
7-May	IG	0.18	<0.33 *	<146.3 *	Empire Canyon Iron Gate Flume
7-May	IG	0.17	<0.33 *	<146.3 *	Empire Canyon Iron Gate Flume
7-May	IG	0.49	1.31	587.93	Empire Canyon Iron Gate Flume
7-May	IG	0.19	<0.33 *	<146.3 *	Empire Canyon Iron Gate Flume
9-May	IG	0.31	0.64	287.23	Empire Canyon Iron Gate Flume
9-May	IG	0.56	1.61	722.57	Empire Canyon Iron Gate Flume
10-May	IG	0.58	1.7	762.96	Empire Canyon Iron Gate Flume
10-May	IG	1.1	4.58	2055.5	Empire Canyon Iron Gate Flume
14-May	IG	1.15	4.91	2203.61	Empire Canyon Iron Gate Flume
14-May	IG	1.26	5.65	2535.72	Empire Canyon Iron Gate Flume, Sample EC-SW-02
18-May	IG	1.3	5.93	2661.38	Empire Canyon Iron Gate Flume
18-May	IG	1.35	6.29	2822.95	Empire Canyon Iron Gate Flume
24-May	IG	0.93	3.53	1584.26	Empire Canyon Iron Gate Flume
23-Apr	WW	Dry	ND	ND	Walker Webster Flume
7-May	WW	Dry	ND	ND	Walker Webster Flume
9-May	WW	0.13	0.14	62.83	Walker Webster Flume
9-May	WW	0.26	0.39	175.03	Walker Webster Flume
10-May	WW	0.25	0.37	166.06	Walker Webster Flume
10-May	WW	0.4	0.76	341.09	Walker Webster Flume
14-May	WW	0.55	1.23	552.02	Walker Webster Flume, Sample EC-SW-08
18-May	WW	0.8	2.18	978.38	Walker Webster Flume
24-May	WW	0.49	1.03	462.26	Walker Webster Flume
24-May	WW	0.48	1	448.8	Walker Webster Flume
4-Jun	WW	0.22	0.19	85.27	Walker Webster Flume
7-Jun	WW	0.1	0.09	40.39	Walker Webster Flume
11-Jun	WW	Dry	ND	ND	Walker Webster Flume

Notes:
DD - Daly Draw (6")
EC - Middle Empire above Judge Tunnel (9"
IG - Lower Empire Canyon at Iron Gate (12")
WW - Walker Webster (9")
* - Less then lowest flow on published discharge tables
ND - None Detected

Table 5, DERR Sample Results
Empire Canyon - Sediment Data

units ppm

Station Location	Water Station Location	AL	SB	AS	BA	BE	CD	CA	CR	CO	CU	FE	PB	MG	MN	HG	NI	K	SE	AG	NA	TL	V	ZN
EC-SD-24	EC-SW-01	6540	36.8J	74.6	91	0.36	25.3	26200	18.6	12.6	154	16800	2960J	8180	1780	0.27	18	881	1.9	17.1	202	2.1	14.1	4830
EC-SD-25	EC-SW-02	6470	80.4J	177	198	0.43	56	32800	19.7	14.9	433	21600	7700J	7880	3860	1.1	17.9	1060	3.4	44.5	199	6.8	15.2	9610
EC-SD-26	EC-SW-04	5870	2.3J	21.6	238	1.8	8.6	2700	12.5	85	21	48300	87.1J	5000	9310	0.07	75.1	356	2.3	3.3	170	1.7	6.3	1580
EC-SD-27	EC-SW-05	5630	50.5J	96.3	60.8	0.23	76.3	54200	29.8	7.3	242	17900	4670J	9840	1040	0.11	8.9	846	2.8	12.5	217	1.1	13.2	15100
EC-SD-28	EC-SW-06	7330	9.4J	22	180	0.51	3.4	9430	19.2	8.4	31.9	10500	322J	3990	1700	0.49	12.9	1140	1.4	4	306	1.4	13.5	345
EC-SD-29	EC-SW-07	8180	140J	276	143	0.43	30.9	29400	18.8	4.9	530	19300	5840J	7130	1670	1.1	10.7	1210	1.9	68.7	265	6.5	18.2	5360
EC-SD-30	EC-SW-08 & 22	5660	82.2J	65.1	101	0.3	117	58100	1.09	2.19	246	28100	13500J	7840	1670	0.24	12.7	933	6.1	26.6	226	1.1	12.8	24200
EC-SD-31	EC-SW-09	13500	55J	79.3	207	0.72	11.8	10500	25.9	9	323	22900	2130J	8870	1510	0.15	14.6	2000	1.2	36	293	1.4	31.9	3170
EC-SD-32	EC-SW-10	6140	94.3J	139	95.9	0.36	16.7	6320	12.5	4.9	314	16100	3380J	3760	1040	0.25	7.5	956	1.1	34.9	179	3.9	13.6	4220
EC-SD-33	EC-SW-11	13200	18.2J	50.5	128	0.6	6.8	16700	24.5	6.6	128	20300	720J	11800	1250	0.13	16	817	1.4	6.5	175	1.1	25.7	1150
EC-SD-34	EC-SW-12	15300	10.4J	39.4	84.8	0.92	2.9	14200	33.5	8.1	61.9	19600	438J	15400	1060	0.14	17.5	1250	1.3	4.9	196	1	31.6	549
EC-SD-35	EC-SW-13	9370	0.83J	22.6	158	0.6U	0.65U	3320	14	8.4	11.9 J	18000	31.9	4400	552	0.07	9	948J	1.2J	0.21UJ	242U	2.9U	28.3	63.4
EC-SD-36	EC-SW-14	11200	0.9J	17.8	170	0.62U	1.2U	4090	27.8	11.3	20.4 J	21700	64.4	6870	1010	0.081	10.8	694J	0.94J	0.48J	202U	5	25.4	119
EC-SD-37	EC-SW-15	11600	0.48J	7.7	58.5	0.6U	0.55U	4070	18	7.7	16.4 J	14700	46.2	12300	523	0.066	15.6	896J	0.70UJ	0.21UJ	187U	2.6U	20.5	101
EC-SD-38	EC-SW-16 & 23	10400	44.3J	49.2	57.4	0.66U	29.7	7310	17	12.9	228 J	17000	3070	10300	939	0.15	14.4	886J	2.5J	9.2J	53.1UJ	2.5U	19.2	6080

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CU and K "J" = SERIAL DILUTION % GREATER THAN 10% AND ORIGIONAL SAMPLE VALUE AT LEAST 50 IDL (Instrument Detection Limit)
SB, AG, AND CU "JJ" = MATRIX SPIKE RECOVERY EXCEED QC LIMITS

Table 6, DERR Sample Results
Empire Canyon - Soil Data

units ppm

Station Location	Location Description	AL	SB	AS	BA	BE	CD	CA	CR	CO	CU	FE	PB	MG	MN	HG	NI	K	SE	AG	NA	TL	V	ZN
EC-SF-40	Mine waste pile in upper Walker Webster	6640	1.3	35.9	41.1	0.79	2	1740	16.4	11.9	22.5	29000	203	7290	1250	0.048	21.5	493	1.4	0.38	320	0.82	18.4	379
EC-SF-41	Deposit downstream of power pole in Walker Webster	3970	188.0	164	76.5	0.2	165	54400	7	23.3	664	30100	17500	6300	1400	0.77	7.3	873	9	44	68.8	0.84	9.3	29200
EC-SF-42	Mine pile (St.Louis Mine) in WW Gulch	4100	0.9	16	35.4	0.44	0.44	53700	128	3.8	18.6	11800	52.6	6760	99.5	0.15	37.4	1970	4.9	0.25	828	0.81	11.5	150
EC-SF-43	Mine waste pile in mid WW Gulch	1840	336.0	79.6	61.5	0.11	110	87100	5.4	9.2	171	13300	11300	5960	1730	0.35	4.6	623	6.2	19.7	70.4	0.86	6.3	18900
EC-SF-44	Above Little Bell mine	12300	1.0	16	192	0.62	0.14	2870	16.9	8.5	12	16800	27	5790	804	0.006	10.8	1710	1.3	1	216	1	28.9	63.2
EC-SF-45	Little Bell mine regraded area	3350	599.0	1170	169	0.2	134	50700	14.6	2.1	2520	8250	22300	22000	5510	5.1	10.9	374	5.5	241	795	2.7	16.4	51600
EC-SF-46	Little Bell mine regraded area	9680	12.0	53.6	166	0.44	5.7	6630	48.7	114	114	9730	513	18200	1560	0.97	20.8	478	1	9.5	230	1	13	1140
EC-SF-47	Daly-Judge mine waste pile	7200	27.4	62.7	27.2	0.34	15.6	78200	55.2	3.6	170	10500	5440	16600	1170	2	12.1	269	2.2	16.5	195	0.99	16.9	2070
EC-SF-48	Daly-Judge mine waste pile	5610	45.1	96.2	45.8	0.3	12.6	57100	35.9	4.8	137	15800	3600	9680	1510	0.82	14.6	588	3.6	19.9	197	1	14.5	2420
EC-SF-49	Daly West mine waste pile	2680	282.0	264	98	0.2	34.2	61700	19.1	14.3	504	16800	4290	10100	2190	1.7	11.6	490	8.9	65.8	11.6	7.2	8.7	5360
EC-SF-50	Daly West mine waste pile	3170	37.8	146	108	108	15.7	72200	23.5	6.3	122	16500	2810	8490	1730	0.37	15.2	367	5.6	25.3	197	5.9	11.2	2410
EC-SF-51	Mine wastes below Daly West above Judge Tunnel	5540	79.6	90.8	209	0.28	29.6	25000	39.6	2.8	991	15100	3930	4740	4720	0.88	9.3	402	1.8	112	409	1	33.5	6980
EC-SF-52	Mine wastes below Daly West above Judge Tunnel	3370	53.1	124	334	0.2	57.9	3900	7	2.3	396	5740	2320	1460	5360	0.81	7.7	524	1.8	62.7	176	1	8.5	4900
EC-SF-53	Mine wastes below Daly West above Judge Tunnel	11100	1.7	10	113	0.46	0.24	85700	37.7	2.9	13.4	9940	50.2	38500	217	0.22	14.4	799	2.3	0.95	361	0.96	15.4	75.3
EC-SF-54	Mine wastes below Daly West above Judge Tunnel	16660	5.7	17.3	471	0.61	1.6	67600	20.7	3.2	83.5	11400	231	8680	956	956	10.4	545	2	8.5	412	1.1	22.1	333
EC-SF-55	Mine wastes below Daly West above Judge Tunnel	6540	415.0	688	107	0.39	128	12300	19.3	4.2	1590	20600	9880	6260	1430	3.8	11.3	848	2.1	177	524	9.7	13.8	19400
EC-SF-56	Mine wastes below Daly West above Judge Tunnel	12200	21.7	74.4	238	0.71	14.1	9850	22.7	8.6	247	19100	1930	7870	2750	0.38	13.7	2180	1.4	13.9	269	1	27.4	2040
EC-SF-57	Mine wastes in Emp.channel between WW confluence and canyon mouth	5890	41.2	66.4	999	0.43	12.5	67200	45	6	502	45700	7660	9630	532	0.39	17.7	948	4.6	23.2	479	0.93	28.4	2820
EC-SF-58	Mine wastes in Emp.channel between WW confluence and canyon mouth	3270	96.5	73.7	55.3	0.21	79.9	66200	13.7	8.9	227	13500	6680	7380	1560	0.15	8	537	3.1	14.2	429	1.6	8.8	13100
EC-SF-59	Mine wastes in Emp.channel between WW confluence and canyon mouth	891	742.0	761	84.4	0.06	133	918	5.1	0.44	1340	81700	171000	1230	186	2.8	1.5	2330	34.7	338	522	7.8	10.5	20600
EC-SF-60	Mine wastes in Emp.channel between WW confluence and canyon mouth	854	93.6	194	337	0.27	127	32200	9.2	6.2	240	11300	5230	13100	9640	4.3	16.1	409	7.7	78.6	326	14.7	7.4	8380
EC-SF-61	Mine wastes in Emp.channel between WW confluence and canyon mouth	7650	21.9	44	85	0.44	4.9	56800	48.5	14.9	163	20300	1850	20100	358	0.2	20	1040	15.7	11	489	1.1	15.8	602
EC-SF-62	Mine wastes in Emp.channel between WW confluence and canyon mouth	2520	338.0	571	62.4	0.07	0.75	47000	39.7	0.46	289	96900	7900	4210	119	0.49	2.3	2290	27.1	42.9	335	1.6	9.8	263
EC-SF-63	Residence at mouth of canyon	8630	4.3	22.4	151	0.57	3.3	4160	14.7	6.7	37.7	13500	291	5940	1140	0.51	15.3	1270	1.1	3.2	391	1.1	17.9	552
EC-SF-64	Residence at mouth of canyon	8360	27.5	74.8	184	0.53	15.7	23900	55.8	7.1	424	33700	1590	8070	2020	1.6	14.6	1920	1.1	14	485	1.1	102	2940
EC-SF-65	Residence at mouth of canyon	14200	30.0	108	204	0.82	36.6	7030	20.7	10.2	275	21500	2670	7080	1340	1.2	19.3	2580	1.3	16.3	313	1.2	29.3	4590

Table 7, Empire Canyon Trail Sampling

units ppm

Date		Location Description	AG	AL	AS	CD	CR	CU	FE	HG	MOIST.	PB	SB	SE	ZN
20-Nov-01	ERA-1	Background soils east of Anchor-Judge Mine waste dump			33							229			
20-Nov-01	ERA-2	Surface of Anchor-Judge mine waste dump			83							2567			
20-Nov-01	ERA-3	Surface of Anchor-Judge mine waste dump	43	11760	198	23	125	610	19110	1.0	13	5267	36	<5	4925
20-Nov-01	ERA-4	On trail downslope from Anchor-Judge			240							7607			
20-Nov-01	ERA-5	Daly West construction area-trail closed			158							3468			
20-Nov-01	ERA-6	Daly West construction area-trail closed			147							4440			
20-Nov-01	ERA-7	On trail east of Daly West	9.9	14050	45	4.7	35	73	22570	0.21	21	745	8.6	<5	596
20-Nov-01	ERA-20	Duplicate of ERA-7	4.9	13600	57	4.5	36	71	23370	0.20	17	616	6.6	<5	565
20-Nov-01	ERA-8	On trail near confluence of Walker Webster and Empire			32							423			
20-Nov-01	ERA-9	In WW approx 150' above flume.			23							349			
20-Nov-01	ERA-10	On trail north of Alliance dump (Background)			57							356			
20-Nov-01	ERA-11	On trail on Alliance dump surface	56	5969	173	11	58	205	107500	0.66	15	15470	40	26	1507
20-Nov-01	ERA-21	Duplicate of ERA-11	105	5052	150	8.4	50	171	106800	0.60	14	18540	39	43	1180
20-Nov-01	ERA-12	On trail on Alliance dump surface			182							758			
20-Nov-01	ERA-13	On trail on Alliance dump surface	44	4966	349	18	27	321	17800	2.1	20	6855	99	<5	2975
20-Nov-01	ERA-14	On trail on Alliance dump surface			392							6019			
20-Nov-01	ERA-15	Ontario Canyon (Background)			63							310			

Samples collected November 20, 2001

Sample ERA-20 is a duplicate of sample ERA-7
Sample ERA-21 is a duplicate of sample ERA-11

empire-all-traildata.xls

Table 8, 1999 and 2000
Empire Canyon
Soils Data

(all units are ppm unless otherwise specified)

Sample ID	Date	Description	Ag	As	Ba	Cd	Cr	Hg (ppb)	Pb	Se	Zn
UP-S-1	4/27/99	TAILINGS COMPOSITE	37	181	209	62	75	2.1	10,910	<10	10,640
UP-S-2	4/27/99	STREAMBED COMPOSITE	20	94	205	87	80	0.75	7,856	10	14,990
UP-S-3	4/27/99	STREAMBED GRAB	9.1	64	164	24	291	0.57	2,250	<10	3,556
UP-S-4	4/27/99	STREAMBED GRAB	9	69	147	27	322	0.69	2,373	<10	3,908
UP-S-5	4/27/99	STREAMBED GRAB	6.6	130	2,210	12	275	0.73	1,449	<10	2,501
UP-S-6	4/27/99	STREAMBED GRAB	15	146	1,594	20	248	0.98	3,622	<10	3,785
UP-S-7	4/27/99	SIDE OF CHANNEL GRAB	37	178	257	76	86	1.7	13,810	<10	12,660
10132	10/17/99	EMPIRE CHANNEL	N/A	N/A	N/A	N/A	N/A	N/A	1,280	N/A	1,900
10133	10/17/99	EMPIRE CHANNEL	N/A	N/A	N/A	N/A	N/A	N/A	1,350	N/A	2,300
10134	10/17/99	DUPLICATE OF SAMPLE 10132	N/A	N/A	N/A	N/A	N/A	N/A	1,200	N/A	1,800

Table 9, 1999 and 2000
Empire Canyon
Water Data
(all units are ppm unless otherwise specified)

Sample ID	Date	Description	Ag	Ag (D)	As	As (D)	Ba	Ba (D)	Ca	Cd	Cd (D)	Cr	Cr (D)	Cu	Cu (D)	Fe	Fe (D)	Hg (ppb)	Hg (D) (ppb)	Mn	Mn (D)	Pb	Pb (D)	pH (su)	Se	Se (D)	Zn	Zn (D)
UP-W-1	5/4/99	Empire channel by Iron Gate	0.044	0.015	0.17	0.15	0.21	0.15	N/A	0.14	0.14	0.021	<0.01	N/A	N/A	N/A	N/A	1.1	N/A	N/A	N/A	25	24	2.9	0.016	0.015	28	27
UP-W-2	5/4/99	Empire channel below Water Tank	<0.01	<0.01	<0.01	<0.01	0.047	0.048	0.041	0.041	<0.01	<0.01	<0.01	N/A	N/A	N/A	N/A	0.5	N/A	N/A	N/A	0.039	0.038	6.8	0.009	0.009	7.4	7.7
UPCM-FLG-1	5/19/99	Emp channel above Judge portal	<0.01	<0.01	0.022	<0.02	0.11	0.094	54	0.02	0.017	<0.02	<0.02	N/A	N/A	N/A	N/A	<0.5	N/A	N/A	N/A	0.3	0.02	7.7	<0.01	<0.01	2.8	2.4
UPCM-FLG-2	5/19/99	Duplicate of UPCM-FLG-1	N/A	<0.01	N/A	<0.02	N/A	0.095	N/A	N/A	0.018	N/A	<0.02	N/A	N/A	N/A	N/A	<0.5	N/A	N/A	N/A	N/A	0.023	7.7	N/A	<0.01	N/A	2.5
EMP-W-KCG	5/21/99	Spring west of channel near Iron Gate	N/A	<0.01	N/A	<0.02	N/A	0.1	N/A	N/A	0.032	N/A	<0.02	N/A	<0.01	N/A	N/A	N/A	<0.5	N/A	N/A	N/A	<0.01	N/A	N/A	<0.02	N/A	6.8
UPCM-FE-1	5/25/99	Daly Draw east of Judge portal	<0.01	<0.01	<0.02	<0.02	0.14	0.085	N/A	<0.005	<0.005	<0.02	<0.02	<0.01	<0.01	N/A	N/A	<0.5	<0.5	N/A	N/A	<0.01	<0.01	8.1	<0.02	<0.02	0.03	0.023
UPCM-FDW-1	5/25/99	Empire channel below Daly West and above air shaft	<0.01	<0.01	<0.02	<0.02	0.17	0.12	N/A	0.016	0.015	<0.02	<0.02	0.019	<0.01	N/A	N/A	<0.5	<0.5	N/A	N/A	0.13	<0.01	7.9	<0.02	<0.02	2.8	2.6
EMP-DALY-EF	6/9/99	East Fork of Empire Channel	<0.01	<0.01	<0.02	<0.02	0.25	0.23	N/A	0.002	0.002	<0.02	<0.02	<0.01	<0.01	N/A	N/A	<0.5	<0.5	N/A	N/A	0.016	0.005	N/A	<0.005	<0.005	0.28	0.21
EMP-DALY-WF	6/9/99	West Fork of Empire	<0.01	<0.01	<0.02	<0.02	0.21	0.19	N/A	0.026	0.029	<0.02	<0.02	0.011	<0.01	N/A	N/A	<0.5	<0.5	N/A	N/A	0.16	0.04	N/A	0.005	0.009	3.7	3.4
UPCM-WWH-1	6/3/99	Hanauer Tunnel	<0.01	<0.01	<0.02	<0.02	0.11	0.099	N/A	<0.005	<0.005	<0.02	<0.02	<0.01	<0.01	N/A	N/A	<0.5	<0.5	N/A	N/A	<0.01	<0.01	N/A	<0.02	<0.02	0.17	0.14
UPCM-WWU-2	6/3/99	Just Below MCConkie ski lift	0.064	<0.01	<0.02	<0.02	0.093	0.082	N/A	<0.005	<0.005	<0.02	<0.02	<0.01	<0.01	N/A	N/A	<0.5	<0.5	N/A	N/A	<0.01	<0.01	N/A	<0.02	<0.02	0.14	0.045
UPCM-WWMD-3	6/3/99	Toe of Walker Webster Mine Dump	<0.01	<0.01	<0.02	<0.02	0.1	0.097	N/A	<0.005	<0.005	<0.02	<0.02	<0.01	<0.01	N/A	N/A	<0.5	<0.5	N/A	N/A	0.016	<0.01	N/A	<0.02	<0.02	0.2	0.17
UPCM-WW-4	6/3/99	Duplicate of UPCM-WWMD-3	<0.01	N/A	<0.02	N/A	0.099	N/A	N/A	<0.005	N/A	<0.02	N/A	<0.01	N/A	N/A	N/A	<0.5	N/A	N/A	N/A	<0.01	N/A	N/A	<0.02	N/A	0.23	N/A
UPCM-WWDS-1	6/3/99	Upper Walker Webster Below Mine Dump	<0.01	<0.01	<0.02	<0.02	0.11	0.1	N/A	0.012	0.011	<0.02	<0.02	0.011	<0.01	N/A	N/A	<0.5	<0.5	N/A	N/A	0.14	0.01	N/A	<0.02	<0.02	1.6	1.4
UPCM-WW-1	5/25/99	500' Upstream of Alliance Tunnel	<0.01	<0.01	<0.02	<0.02	0.16	0.08	N/A	0.021	0.01	<0.02	<0.02	0.053	<0.01	N/A	N/A	<0.5	<0.5	N/A	N/A	2	0.041	N/A	<0.02	<0.02	3.3	1.2
WW-3A/3B	6/24/99	WW gulch near power pole	<0.01	<0.01	<0.02	<0.02	N/A	N/A	N/A	0.005	0.005	N/A	N/A	<0.01	<0.01	0.079	<0.02	N/A	N/A	<0.02	<0.02	0.023	0.006	N/A	N/A	N/A	0.71	0.75
WW-4A	6/24/99	WW near McConkie lift	<0.01	N/A	<0.02	N/A	N/A	N/A	N/A	<0.001	N/A	N/A	N/A	<0.01	N/A	0.15	N/A	N/A	N/A	<0.02	N/A	0.016	N/A	N/A	N/A	N/A	0.058	N/A
AT-1A/1B	6/24/99	Walker Webster Flume	<0.01	<0.01	<0.02	<0.02	N/A	N/A	N/A	0.007	0.007	N/A	N/A	<0.01	<0.01	0.21	<0.02	N/A	N/A	<0.02	<0.02	0.15	0.03	N/A	N/A	N/A	0.86	0.72
WW-1A/1B	6/24/99	Walker Webster at toe of mine dump	<0.01	<0.01	<0.02	<0.02	N/A	N/A	N/A	<0.01	<0.001	N/A	N/A	<0.01	<0.01	0.2	<0.02	N/A	N/A	0.03	<0.02	0.024	<0.005	N/A	N/A	N/A	0.13	0.12
WW-2A/2B	6/24/99	WW channel on east side of mine dump	<0.01	<0.01	<0.02	<0.02	N/A	N/A	N/A	<0.01	<0.001	N/A	N/A	<0.01	<0.01	<0.02	<0.02	N/A	N/A	<0.02	<0.02	0.005	<0.005	N/A	N/A	N/A	0.039	0.044

Table 10, Empire Canyon Analytical Results Summary, May 2002

units mg/l except for Hg - ng/l

Date	Sample #	Location Description	AL	AL(D)	ALK.	AS	AS(D)	CA	CAT/AN BAL.	CD	CD(D)	CL-	CO3	COND.	CU	CU(D)	FE	FE(D)	HARD	HCO3	HG	HG(D)	K	MG	NA	PB	PB(D)	SB	SB(D)	SO4=	TDS	TSS	[illegible]	ZN(D)
6-May-02	ECA-SW-01	At flume near Iron Gate	0.065	<0.050	94	0.008	0.008	70	4.1	0.01	0.01	16	<1.0	442	0.013	0.005	0.31	<0.10	215	94	<0.000	<0.0002	<2.0	9 7	5 5	0 024	<0 005	0 012	0 012	105	297	<1.0	1 9	1 9
6-May-02	ECA-SW-02	Culvert from Daly Draw at Emp Channel		<0.050			<0.005				0 006					<0.005		<0.10				<0.0002					<0.005		0 006					1
6-May-02	ECA-SW-03	Daly Draw flume		<0.050			<0.005				<0.001					<0.005		<0.10				<0.0002					<0 005		<0.005					<0.010
6-May-02	ECA-SW-503	Dup of SW-03		<0.050			<0.005				<0.001					<0.005		<0.10				<0.0002					<0 005		<0 005					<0 010
6-May-02	ECA-SW-04	Flume at Walker Webster	2.1	<0.050	77	0.02	<0.005	62	10.9	0.037	0.029	2.3	<1.0	327	0.075	<0.005	3.6	<0.10	187	77	<0.000	<0.0002	<2.0	7.8	2.1	3.4	0.098	0.055	0.013	84	222	149	6.9	4
6-May-02	ECA-SW-05	Upstream of Daly West	68	<0.050		0.31	<0.005			0.032	<0.001				0.7	<0.005	73	<0.10			<0.000	<0.0002				4 4	0.006	0.18	0.005				5.7	<0 010
6-May-02	ECA-SW-06	Culvert at toe of Daly West	47	0.071		0.19	0.008			0.02	<0.001				0 45	0.006	50	<0.10			<0.000	<0.0002				2 7	0.012	0 12	0.008				3.7	<0 010
6-May-02	ECA-SW-TOF	Park City Municipal Water Tank in Empire Canyon-overflow	<0.050	<0.050	106	0.009	<0.005	65	8.9	0.003	0.003	3.6	<1 0	394	0 022	0.006	0.49	<0.10	201	106	<0.000	<0 0002	<2.0	9 5	4 3	0 005	<0 005	0 007	0 007	81	260	3 1	0.93	0 89
7-May-02	JUDGE TUNNEL(a)		< 050	<.050	108	0.01	<.005	71	13	0.003	0.003	3.2	<1 0	412	0 031	0.019	0 44	<.10	219	108	<.20	<.20	<2.0	10	4 3	0 009	< 005	0 006	0 006	80	357	<1 0	0 88	0 97
7-May-02	WALKER WEBSTER(a)	Flume at Walker Webster		<.050			< 005				0.035					0.027		<.10				< 20					0 13		0 013					4 5
8-May-02	ECA-SW-06	Culvert at toe of Daly West	13	059	46	.038	.006	24	9.9	.004	<.001	3.8	<1.0	163	.11	.034	15	<.10	71	46	<.20	< 20	2.3	2 6	7.3	60	006	028	006	29	99	341	.88	019
8-May-02	ECA-SW-506	Dup of SW-06	13	<.050	44	.038	.006	24	10.5	.004	< 001	6.4	<1.0	159	.11	.011	15	<.10	71	44	<.20	<.20	2.1	2 6	7 3	58	007	027	005	26	92	316	.86	< 010
8-May-02	ECA-SW-07	Emp channel just above air shaft	.064	<.050	99	.006	.005	76	7.9	.023	.025	22	<1.0	468	.025	.042	.15	<.10	23 1	99	<.20	<.20	<2.0	10	6.5	041	.027	025	.026	93	304	1.3	4 0	4.1
8-May-02	ECA-SW-08	Emp channelabove SW-07	.11	<.050		.006	.006			.030	.031				.040	.016	<.10	<.10			<.20	<.20				.024	.012	040	039				4 7	4 8
8-May-02	ECA-SW-09	Emp channel above SW-08	.42	<.050		.005	<.005			.023	.025				.022	.009	.36	<.10			<.20	<.20				.065	.007	.028	.027				4 2	4.3
8-May-02	ECA-SW-10	Emp channel above SW-09	.22	<.050		.006	<.005			.032	.033				.023	.010	.17	<.10			<.20	<.20				064	012	032	.031				6 0	6.1
8-May-02	ECA-SW-11	Emp channel above SW-10	.085	<.050		<.005	<.005			.032	.036				.029	.014	<.10	<.10			<.20	<.20				.069	.027	029	029				6.6	6.7
29-May-02	WW-1 (a)	WW Gulch near power pole																																0.76
29-May-02	WW-2 (a)	WW Gulch seeps along channel																																0.074
29-May-02	WW-3 (a)	WW Gulch above power pole																																0.73
29-May-02	WW-4 (a)	Upper WW Gulch																																0.74
29-May-02	WW-5 (a)	Upper WW Gulch																																0.081
29-May-02	WW-6 (a)	Upper WW Gulch																																0.046
29-May-02	WW-7 (a)	Upper WW Gulch below Keystone dump																																0.091
29-May-02	WW-8 (a)	In channel north side of Keystone Dump																																0.14

Notes:
Sample ECA-SW-503 is a duplicate of ECA-SW-3
Sample ECA-SW-506 is a duplicate of ECA-SW-6

Tabbed Page: Appendix 1

APPENDIX 1
DATA VALIDATION REPORT

DATA QUALITY ASSESSMENT

Empire Canyon EE/CA
United Park City Mines

INTRODUCTION

This report presents the results of the data quality assessment of analytical data for samples collected between May 4, 1999 and May 29, 2002. These data were used in the Site Characterization Report which is included in the *Engineering Evaluation/Cost Analysis (EE/CA) for Empire Canyon* (RMC, 2002). The sampling activities generally followed the Sampling and *Analysis Plan for Empire Canyon (SAP)* (Environmental Resource Management Consultants dba RMC, July 17, 2002).

The data quality assessment process evaluates whether the specific requirements for an intended use have been fulfilled and ensures that the results conform to the user's needs. This report summarizes the review of sampling and analysis to assess conformance with QC requirements for this project. This data evaluation is presented in terms of the PARCC criteria and is based on the *U.S. EPA Functional Guidelines for Inorganic Data Review* (U.S. EPA, 1994), *Guidance for the Data Quality Assessment Process* (EPA QA/G-9), and on the quality control limits established by the analytical laboratory or as specified by the specific analytical method. The analytical results were evaluated against data quality objectives (DQOs), which are quantitative and qualitative statements that specify data quality and are expressed in terms of precision, accuracy, representativeness, comparability, and completeness (PARCC). Tables 1 and 3 of the SAP describe the DQOs and QA/QC goals for this project. Table 4 of the SAP presents the data validation and verification requirements for this project.

Six sets of data were used in the EE/CA:

1. Water samples collected between May 6, 2002 and May 29, 2002
2. Water samples collected between May 4, 1999 and June 24, 1999
3. Soil samples collected on April 27, 1999 and October 17, 1999
4. Soil samples from the Empire Canyon trail sampling project conducted November 20, 2001
5. Water samples from the Upper Silver Creek Watershed Study collected May 16, 2000 and May 31, 2000
6. Sediment samples from the Upper Silver Creek Watershed Study collected September 28, 2000.

Although the water samples collected between May 6, 2002 and May 29, 2002 were the only samples officially collected under the SAP, to the extent possible, analytical results from Sample Sets 2, 3 and 4 were also reviewed and validated in this report. Data quality for samples from the Upper Silver Creek Watershed Study was evaluated in the *Data Review Report for the Upper Silver Creek Watershed Stakeholders Group, Sampling Round 2* (RMC, 2001)

American Environmental Consultants (AEC) Laboratory in Salt Lake City performed the analyses.

As specified in Table 4 of the SAP, data were assessed according to the following steps:

1. Were samples collected according to established locations and frequencies?
2. Were samples collected and handled following established procedures?
3. Were appropriate analytical methods used?
4. Were holding times and laboratory reporting limits met?
5. Did field duplicate results meet acceptance criteria?
6. Did field QC samples (field blanks, equipment/rinsate blanks) meet acceptance criteria?
7. Did laboratory QC samples (method blanks, laboratory control samples (LCS), matrix spike (MS) and matrix spike duplicate (MSD) samples, cation/anion balance for water samples) meet acceptance criteria?
8. Were appropriate steps taken to ensure the accuracy of data reduction, including reducing data transfer errors in the preparation of summary data tables and maps.

The following sections of this report summarize the data validation results following the list of data validation and verification steps listed above. The final section of this report summarizes the data validation results in terms of PARCC criteria, including completeness calculations expressing the percent complete of valid data compared to the total number of samples collected. This section also makes recommendations for suggested alterations to the sampling and analysis program to improve data collection and analytical protocols in the event additional sampling is conducted.

The samples collected, sample dates, parameters analyzed, and laboratory sample numbers are provided in data tables in the EE/CA. The laboratory analytical reports, including the laboratory quality control data, are provided in Appendix A (Site Characterization Report) of the EE/CA.

SAMPLING LOCATIONS AND FREQUENCIES

Samples were generally collected at the locations and frequencies specified in the SAP. Refer to tables in the Site Characterization Report for a complete listing of samples collected and parameters analyzed. In some cases, additional metals not specified in the SAP, such as aluminum, barium and chromium, were analyzed in addition to the parameters listed on Table 2 of the SAP.

Data Set 1 - Water samples collected between May 6, 2002 and May 29, 2002
Seventeen water samples (including two duplicates) were collected by RMC on May 6, 7, 8, 2002. These samples were analyzed for the complete list or a subset of parameters specified in Table 2 of the SAP. Eight additional water samples (no duplicates) were collected by UPCM personnel on May 29, 2002 and analyzed for dissolved zinc only.

Data Set 2 - Water samples collected between May 4, 1999 and June 24, 1999
Twenty-one water samples (including two duplicates) were collected by RMC between May 4, 1999 and June 24, 1999, before the preparation of the SAP. These samples were analyzed for a complete or subset of total and dissolved Ag, As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Pb, Se, and Zn. Some samples were also analyzed for total calcium and pH.

Data Set 3 - Soil samples collected on April 27, 1999 and October 17, 1999
Ten soil samples (including one duplicate) were collected by RMC on April 27, 1999 and October 17, 1999, before the preparation of the SAP. Seven of these samples were analyzed for Ag, As, Ba, Cd, Cr, Hg, Pb, Se, and Zn. The remaining three samples (including the one duplicate) were analyzed for Pb and Zn only.

Data Set 4 - Soil samples from the Empire Canyon trail sampling project conducted November 20, 2001

Seventeen soil samples (including two duplicates) were collected by RMC on November 20, 2001, before the preparation of the SAP. Six of these samples (including the two duplicates) were analyzed for Ag, Al, As, Cd, Cr, Cu, Fe, Hg, Pb, Sb, Se, and Zn. The remaining 11 samples were analyzed for As and Pb only.

SAMPLE COLLECTION AND HANDLING

Samples were collected and handled in accordance with the procedures described in the SAP. Sample collection and handling procedures were documented in field notes and chain-of-custody/laboratory request forms.

ANALYTICAL METHODS

The EPA-approved analytical methods listed in Table 2 of the SAP were used in all but one case. Analyses performed for total zinc from one batch of samples collected June 3, 1999 (before the SAP was prepared) were analyzed using EPA Method 289.1 (Flame Atomic Adsorption) rather than 6010B specified in the SAP. According to Vince Keller at AEC Laboratories (personal communication, August 15, 2002), this method was probably used because an interference issue was noted with the 6010B method. The laboratory performed internal laboratory calibration checks according to the method-specified protocols. Case narratives were compiled in the analyst's logbook, in digestion logs, and as raw data.

HOLDING TIMES AND LABORATORY REPORTING LIMITS

Holding time reflects the length of time after sample collection that a sample or extract remains representative of environmental conditions. Holding times were compared to standard method-specific holding times accepted by the EPA as listed in Table 2 of the SAP. Data for samples that were extracted and analyzed within holding time criteria are considered representative. For samples that were extracted or analyzed outside of holding criteria, the sample data are qualitatively evaluated to determine the potential effect of the holding time violation on sample representativeness. All holding times were met for all analytical parameters.

The reporting limits specified in the SAP (Table 2) were met in for all analyses performed for Data Sets 1 and 4. However, the following analyses from Data Sets 2 and 3 had Laboratory Reporting Limits (LRLs) that exceeded the reporting limits specified in the SAP:

- Data Set 2, collected before the SAP was prepared, had higher than specified LRLs for arsenic (0.02 mg/l compared to the specified 0.005 mg/l), copper (0.01 mg/l compared to the specified 0.005 mg/l), and mercury (0.0005 mg/l compared to the specified 0.0002 mg/l). Two of the samples (UP-W-1 and UP-W-2) also had an elevated LRL for cadmium: 0.01 mg/l compared to the specified 0.001 mg/l.
- Data Set 3, collected on April 27, 1999 before the SAP was prepared, had a LRL of 1.0 mg/l for cadmium compared to the specified LRL of 0.5 mg/l. However, since all samples contained detectable concentrations of cadmium, this does not pose a data limitation..

FIELD DUPLICATE SAMPLES

Blind field duplicates were collected for all data sets. The frequency of duplicate collection specified in the SAP is ten percent. Tables 1 through 4 summarize the relative percent difference (RPD) calculations for the duplicates collected for each data set. Duplicate results that exceed the QA/QC goal of 35 percent (if > 5 times LRL) or +/- LRL (if < 5 times LRL) are noted in bold. The field duplicate results are discussed below on a data set basis.

Data Set 1 - Water samples collected between May 6, 2002 and May 29, 2002

Field duplicate samples were collected of frequency at the 12 percent for Data Set 1 samples collected by RMC, although no duplicates were collected for the eight dissolved zinc samples collected directly by UPCM.

The calculated relative percent differences (RPDs) for the duplicate samples are provided in Table 1. Overall the field duplicate results were good. However, the calculated relative percent difference (RPD) for dissolved copper for one of the samples exceeded acceptance criteria.

Data Set 2 - Water samples collected between May 4, 1999 and June 24, 1999

Field duplicate samples were collected at a frequency of 10.5 percent for Data Set 2 samples.

The calculated relative percent differences (RPDs) for the duplicate samples are provided in Table 2. The calculated relative percent differences (RPDs) met acceptance criteria in all cases.

Data Set 3 - Soil samples collected on April 27, 1999 and October 17, 1999

Field duplicate samples were collected at a frequency of 11 percent for Data Set 3 samples, however the duplicate set was only analyzed for lead and zinc.

The calculated relative percent differences (RPDs) for the duplicate samples are provided in Table 3. The calculated relative percent differences (RPDs) met acceptance criteria in all cases.

Data Set 4 - Soil samples from the Empire Canyon trail sampling project conducted November 20, 2001

Field duplicate samples were collected at a frequency of 13 percent for Data Set 3 samples.

The calculated relative percent difference (RPD) for the duplicate samples are provided in Table 4. Overall the field duplicate results were good. However, the calculated relative percent difference (RPD) for silver and selenium for one of the samples exceeded the acceptance criteria of 35 percent. This is common for duplicate soil samples where it is difficult to completely homogenize heterogeneous soils and does not suggest a serious data limitation.

FIELD QC SAMPLES

No field QC blanks were collected during this project. Because disposal or dedicated equipment was used at all sampling locations, no equipment/rinsate blanks were required.

LABORATORY QC SAMPLES

AEC Laboratory analyzed matrix spike/matrix spike duplicate, method (prep) blank, and laboratory control samples for most sample batches to evaluate data quality. However, no QC data are available for Data Set 3, collected before the SAP was prepared. The frequency of MS/MSD samples met the goal of ten percent specified in the revised SAP.

Laboratory Control Samples. Laboratory control samples were analyzed for each laboratory sample batch by each laboratory. All of the recoveries for the laboratory control samples were within method-specified control limits.

Matrix Spike Samples. A matrix spike sample was analyzed for each laboratory sample batch by AEC Laboratory. All of the spike recoveries for matrix spike samples were within method-specified control limits. Laboratory RPDs for MS/MSDs were all well within method-specified control limits indicating good precision.

Method (Prep) Blanks. A method or prep blank sample was analyzed for each laboratory sample batch. With two minor exceptions, no analytes were detected in any of the method blanks analyzed by AEC Laboratories indicating that no laboratory contamination was present. For one of the Data Set 1 sample batches, iron at the LRL of 0.10 mg/l and zinc at 0.012 mg/l (just above the LRL of 0.01 mg/l) were detected in the prep blank. However, since some of the samples in this batch reported concentrations less than the LRLs, the detection of iron and zinc in the prep blank does not appear to have caused false positives to be reported.

Cation/Anion Balance

AEC Laboratory calculated cation/anion balances for the seven water samples where all major ions were analyzed. The cation/anion balances for these samples are all within +/- 13 percent (ranging from 4.1 to 13 percent), indicating good major ion balances. This result indicates that the major ion data can be used with a reasonably high degree of confidence.

DATA REDUCTION

For the purposes of developing a database and preparing summary tables for reports, all laboratory data was transferred from the laboratory in electronic form.

DATA VALIDATION SUMMARY

This section summarizes the data validation results in terms of PARCC (Precision, Accuracy, Representativeness, Comparability, and Completeness) criteria, including completeness calculations expressing the percent complete of valid data compared to the total number of samples collected. These results are then compared to the project QA/QC goals (Table 3 of SAP).

PARCC Criteria Summary

Precision. Based on the results of the field duplicates, laboratory duplicates, and matrix spike/matrix spike duplicate results, the water data are precise. The available data along with other measurements of precision indicate that the data can be used with a high degree of confidence.

Based on the results of available field duplicates, laboratory duplicates, and matrix spike/matrix spike duplicate results, the soil data are precise. The available data along with other measurements of precision indicate that the data can be used with a high degree of confidence.

Accuracy. Based on the percent recoveries of the MS/MSD and laboratory control samples, the data can be considered accurate. The data can be used with a high degree of confidence.

Representativeness. Based on the results of the holding time review, method blank data, and blind field duplicate sample data evaluation, the water data for this project can be considered representative of water quality conditions at the site.

Based on the results of the holding time review, method blank data, and blind field duplicate sample data evaluation, the soil data are precise. The available data along with other measurements of precision indicate that the data can be used with a high degree of confidence.

Comparability. Standard methods of sample collection and standard units of measure were used during this project. The analyses performed by the laboratory were in accordance with current SW-846 and other U.S. EPA methodology.

Completeness. Based on the results of the data validation, all data are considered valid without qualification. However, Data Set 3 soils data should probably be considered order-of-magnitude estimates because no laboratory QC data are available for validation.

Table 1
Field Duplicate Summary
Data Set 1 - Water Samples

(units mg/l unless specified)

Date	Sample #	Location Description	AL	AL(D)	ALK.	AS	AS(D)	CA	CATION/ ANION BAL.	CD	CD(D)	CL-	CO3	COND.	CU	CU(D)	FE	FE(D)	HARD	HCO3	HG (ug/l)	HG(D) (ug/l)	K	MG	NA	PB	PB(D)	SB	SB(D)	SO4=	TDS	TSS	ZN	ZN(D)
6-May-02	ECA-SW-03	Daly Draw flume		<0.050			<0.005				<0.001					<0.005		<0.10				<0.0002					<0 005		<0.005					<0.010
6-May-02	ECA-SW-503	Dup of SW-03		<0.050			<0.005				<0.001					<0.005		<0.10				<0.0002					<0 005		<0.005					<0 010
		RPD (%)		NC			NC				NC					NC		NC				NC					NC		NC					NC
8-May-02	ECA-SW-06	Culvert at toe of Daly West	13	.059	46	.038	.006	24	9.9	.004	<.001	3.8	<1.0	163	.11	.034	15	<.10	71	46	<.20	<.20	2.3	2.6	7.3	.60	.006	.028	.006	29	99	341	.88	.019
8-May-02	ECA-SW-506	Dup of SW-06	13	<.050	44	.036	.006	24	10.5	.004	<.001	6.4	<1.0	159	.11	.011	15	<.10	71	44	<.20	<.20	2.1	2.6	7.3	.58	.007	.027	.005	26	92	316	.86	< 010
		RPD (%)	0.0	NC	4.4	5.4	0.0	0.0	5.9	0.0	NC	51.0	NC	2.5	0.0	102.2	0.0	NC	0.0	4.4	NC	NC	9.1	0 0	0 0	3 4	15.4	3.6	18.2	10.9	7.3	7.6	2.3	NC

Table 2
Field Duplicate Summary
Data Set 2 - Water Samples

(units mg/l unless specified)

Sample ID	Date	Location Description	Ag	Ag (D)	As	As (D)	Ba	Ba (D)	Ca	Cd	Cd (D)	Cr	Cr (D)	Cu	Cu (D)	Fe	Fe (D)	Hg (ug/l)	Hg (D) (ug/l)	Mn	Mn (D)	Pb	Pb (D)	pH (su)	Se	Se (D)	Zn	Zn (D)
UPCM-FLG-1	5/19/99	Emp channel above Judge portal	<0.01	<0.01	0.022	<0.02	0.11	0.094	54	0.02	0.017	<0.02	<0.02	N/A	N/A	N/A	N/A	<0.5	N/A	N/A	N/A	0.3	0 02	7 7	<0 01	<0 01	2.8	2 4
UPCM-FLG-2	5/19/99	Duplicate of UPCM-FLG-1	N/A	<0.01	N/A	<0.02	N/A	0 095	N/A	N/A	0.018	N/A	<0.02	N/A	N/A	N/A	N/A	<0.5	N/A	N/A	N/A	N/A	0.023	7 7	N/A	<0.01	N/A	2 5
		RPD (%)	NC	NC	NC	NC	NC	1.1	NC	NC	5.7	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	14.0	0 0	NC	NC	NC	4 1
UPCM-WWMD-3	6/3/99	Toe of Walker Webster Mine Dump	<0.01	<0.01	<0.02	<0.02	0.1	0 097	N/A	<0.005	<0.005	<0.02	<0.02	<0.01	<0.01	N/A	N/A	<0.5	<0.5	N/A	N/A	0.016	<0.01	N/A	<0.02	<0 02	0.2	0 17
UPCM-WW-4	6/3/99	Duplicate of UPCM-WWMD-3	<0.01	N/A	<0.02	N/A	0.099	N/A	N/A	<0.005	N/A	<0.02	N/A	<0.01	N/A	N/A	N/A	<0.5	N/A	N/A	N/A	<0.01	N/A	N/A	<0 02	N/A	0 23	N/A
		RPD (%)	NC	NC	NC	NC	1.0	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	14 0	NC

NC - Not Calculated

Table 3
Field Duplicate Summary
Data Set 3 - Soil Samples

(units ppm unless specified)

Sample ID	Date	Location Description	Ag	As	Ba	Cd	Cr	Hg (ppb)	Pb	Se	Zn
10132	10/17/99	EMPIRE CHANNEL	N/A	N/A	N/A	N/A	N/A	N/A	1,280	N/A	1,900
10134	10/17/99	DUPLICATE OF SAMPLE 10132	N/A	N/A	N/A	N/A	N/A	N/A	1,200	N/A	1,800
		RPD (%)							6.5		5.4

NC - Not Calculated

Table 4
Field Duplicate Summary
Data Set 4 - Soil Samples

(units ppm unless specified)

Lab #	Sample ID	Date	Location Description	AG	AL	AS	CD	CR	CU	FE	HG	MOIST. (%)	PB	SB	SE	ZN
L011583-003	ERA-7	11/20/01	On trail east of Daly West	9.9	14050	45	4.7	35	73	22570	0.21	21	745	8.6	<5	596
L011583-004	ERA-20	11/20/01	Duplicate of ERA-7	4.9	13600	57	4.5	36	71	23370	0.20	17	616	6.6	<5	565
			RPD (%)	67.6	3.3	23.5	4.3	2.8	2.8	3.5	4.9	21.1	19.0	26.3	NC	5.3
L011583-006	ERA-11	11/20/01	On trail on Alliance dump surface	56	5969	173	11	58	205	107500	0.66	15	15470	40	26	1507
L011583-005	ERA-21	11/20/01	Duplicate of ERA-11	105	5052	150	8.4	50	171	106800	0.60	14	18540	39	43	1180
			RPD (%)	60.9	16.6	14.2	26.8	14.8	18.1	0.7	9.5	6.9	18.1	2.5	49.3	24.3

NC - Not Calculated

Tabbed Page: Appendix 2

APPENDIX 2
LABORATORY ANALYTICAL REPORTS
(Will be Supplied Upon Request)

Tabbed Page: Appendix 3

APPENDIX 3
UTAH DERR Tracer Test Report

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ATTACHMENT A

TRACER STUDY RESULTS REPORT

for

EXPANDED SITE INSPECTION ANALYTICAL RESULTS REPORT

EMPIRE CANYON

Summit County, Utah

UT0002005981

Utah Department of Environmental Quality
Division of Environmental Response and Remediation
Prepared by: Ann Tillia

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TRACER STUDY RESULTS REPORT

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ATTACHMENT A

Tracer Study Results Report

Empire Canyon
Expanded Site Inspection
Park City, Summit County, Utah
UT0002005981

Utah Department of Environmental Quality
Division of Environmental Response and Remediation
Prepared by: Ann M. Tillia

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1.0 INTRODUCTION.

Under authority of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) of 1980, the Superfund Amendments and Reauthorization Act (SARA) of 1986, in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and through a Cooperative Agreement with the U.S. Environmental Protection Agency, Region VIII (EPA), the Utah Department of Environmental Quality (UDEQ), Division of Environmental Response and Remediation (DERR) conducted a tracer study as part of the **Empire Canyon Expanded Site Inspection (ESI)**, EPA ID# UT0002005981, located near Park City in Summit County, Utah.

2.0 OBJECTIVES.

The intent of the tracer study was to establish a hydrologic connection between the water in the stream channel upstream and downstream from the mine waste (or tailings) within the Empire Canyon ESI area (Figure 1). Within the study area some stream reaches have been left unchanged since the historical mines operated, and some reaches have been altered in an attempt to divert water away from the mine waste. The hydrology of the study area is a highly dynamic system with several environments conducive to ground water movement. The ground water is collected in the mine tunnels for municipal use in Park City. Ground water emerges from seeps and springs in ephemeral stream channels in response to available ground water and seasonal meteorological conditions. Sample sites and features of interest were mapped with Global Positioning System (GPS) and ArcView Geographic Information System (GIS) technologies.

A salt tracer study described in Section 4.1 was conducted in Daly Draw. The salt tracer results are shown in Figure 2. A fluorescent dye, Rhodamine WT, was chosen as the tracer for the remainder of the study based on the work schedule, the medium of the tracer pathway, and best professional judgment. The dye tracer study was completed in two phases that were determined by the site area and the environmental conditions (Figure 1). Phase I was completed in May 2001 in the lower reaches of Walker-Webster Gulch and Empire Canyon. The results from Phase I are shown in Tables 1 through 5b, and Charts 1 through 7. Phase II was completed in July 2001 in the upper reaches of Walker-Webster Gulch near the McConkie ski lift in the Park City ski area. The results from Phase II are shown in Tables 6 through 9, and Charts 8 through 13.

Water data collected during the study includes specific conductivity, pH, temperature, and dissolved oxygen. The Phase I water data is shown in Tables 4a and 4b. The Phase II water data is shown in Table 9. Stream flow data, calculated from measurements taken from existing flumes in Phase I, are shown in Tables 5a and 5b.

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3.0 BACKGROUND INFORMATION.

3.2 Site Location and Description.

Empire Canyon trends southwest-northeast and Walker-Webster Gulch initially trends west in the lower reaches and then curves, trending southwest in the upper reaches (Figure 1). The Judge Tunnel portal is near the bottom of Empire Canyon at its confluence with Daly Draw from the east and Walker-Webster Gulch from the west. In the Phase I site area, the lower reaches of Walker-Webster Gulch includes an artificial (reconstructed), unlined stream channel consisting of angular quartzite cobbles. Below the Walker-Webster flume a second culvert discharges approximately 4 feet above the ground and adjacent to the stream channel at the confluence with Empire Canyon. Below the Walker-Webster and Empire Canyon confluence the stream channel consists of angular limestone and quartz cobbles downgradient to the third culvert. A third culvert discharges to the first of three artificial pools near the municipal reservoir. In past years, west of the first pool, a seep or spring appeared in cracks in a cement wall, which is the remains of a building foundation (Gee, 2001). The third pool receives the overflow from the municipal reservoir and turnout water from the Judge Tunnel. Downstream from the pools the stream channel winds around a bend with large boulders and continues down a relatively straight stream channel to the iron gate flume. A dirt access road parallels the stream downgradient of the municipal reservoir. The steep slope east of the road and upgradient of the iron gate is comprised of mine tailings. At the downstream end of the tailings slope, the iron gate restricts vehicular traffic up the canyon to Park City maintenance crews and mine employees. Downstream of the iron gate is a flume after which the stream parallels the road into the south end of Park City.

The Phase II site area is within the upper reaches of Walker-Webster Gulch. During Phase II the ephemeral stream exhibited higher flows near seeps and springs that decreased shortly downgradient, loosing surface flow into the soil or unconsolidated gravel and cobble filled stream channel. Approximately 250 feet above the Phase II dye injection point, a three-inch pipe emerged from the east bank and produced a continuous flow during the study. Approximately 30 feet downgradient of the Phase II dye injection point the stream disappeared under a pile of fallen trees and reappeared 560 feet downstream near the ore bin. Between the Phase II dye injection point and ore-bin pool, the stream channel consists of cobble-sized rocks to fine gravels overlying dark organic soils surrounded by abundant vegetation along its banks. A spring emerges adjacent to the ore bin and several feet up the east slope of the stream channel. The flow from the spring quickly disappears into the soil and cobbles in the stream channel before reaching the ore-bin pool 188 feet downgradient. The stream channel between the ore bin and Phase II dye injection point was mostly dry throughout Phase II. Below the ore-bin pool the stream channel has been altered with the construction of the ski run and efforts to divert the surface water around mine waste. The reconstruction of the stream channel was accomplished by installing poly-liners, fine sediment, and/or rip-wrap in the streambed (Gee, 2001).

3.2 Geology.

In the site area, the Ankara Formation and a shale unit of the Park City Formation are considered to be confining units. Geologic units within the site with a high capacity to store and transmit water are the Thaynes, Woodside and Weber Formations. Igneous intrusions into the sedimentary units had metamorphic influences as well as structural effects within the contact zone. Within the contact zone faulted and highly fractured rock created pathways for ground water. The glacial and alluvial deposits that cover much of the canyon floor also may be conducive to the flow of water (Weston Engineering, Inc., 1997).

The structural geology of the region includes several faults that generally trend east-west. The project area lies within the more than two-mile wide west limb of the north to northeast-trending Park City Anticline. The anticline incurred minor faulting and folding as it rose. Two branches of the Crescent Fault traverse and parallel Walker-Webster Gulch in the Phase II site area and are hidden beneath a thin covering of glacial, landside, colluvium, and talus deposits (Weston, 1997). A concealed section of the Crescent Fault crosses the Walker-Webster Gulch stream channel between the culvert and the spring near the aspen and again approximately 80 feet below the most downstream Phase II sampling site. Faulting, folding, and the resulting fractures and joints in the rock units provide a highly permeable environment to store and/or transmit water (Weston Engineering, Inc., 1997).

3.3 Hydrology.
Excess water in the mine tunnels was a problem from the onset of mining the area, and dewatering was necessary. To alleviate the subsurface water problem, the Judge Tunnel was constructed in the late 1880's. The flow from Judge Tunnel averaged 850 gallons per minute (gpm) for the years 1988 through 1991 (Weston Engineering, 1997). During the study, the highest flow recorded below the tunnel was 2,822 gpm on May 18. Water from the Judge Tunnel is stored in a reservoir (above ground tank) for use in the Park City municipal water system. Before the water reaches the municipal reservoir, it is checked with a turbidity meter. If the turbidity is high the water collected in the tunnel is turned out into the Empire Canyon stream, which is a tributary to Silver Creek.

The municipal reservoir is located in the Phase I site area between two sampling sites and discharges into the third of three artificial pools created in the stream channel. During the study, the times and duration that water from the tunnel was turned out to the stream was not extensively documented. Water turned out from the tunnel into the stream channel was noted, when possible, in relation to flow rates or the natural appearance of the surface water (Tables 4a and 4b). The relationship of the tunnel's discharge and the dilution of samples analyzed for dye concentration is minimal with respect to the recovery curve of the dye results shown in the charts (see Section 6.3, Phase I Summary).

The highly dynamic ephemeral stream above and below the confluence in Empire Canyon is supplied by springs and seeps (Appendix A). Although the commencement, duration, and quantity of the stream flow varies greatly year to year, if surface water flow occurs, it generally starts with the first signs of spring thaw in late April or early May. It is in the ephemeral streams that the tracer studies were conducted. During the study, the first stream flow through the flume at the bottom of Walker-Webster Gulch began at approximately 15:30 on May 9 with the onset of spring run-off. The aforementioned flume initially produced 63 gpm and increased to 175 gpm by 21:15 on May 9. Surface water flow through the Walker-Webster Gulch flume peaked at 978 gpm around May 18 and by June 11 the flume was dry, as were the Daly Draw and Empire Canyon flumes. The stream channels in the Phase II site area were dry by July 2 (Table 4b).

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4.0 TRACERS.

4.1 Sodium Chloride (Salt).

On April 30, 2001, most of the project site area was covered with several feet of snow. However, the sound of flowing water was heard 121 feet above the Daly Draw flume. A footstep in the snow produced a hole showing an ample stream flow under the snow although it did not appear at the exposed Daly Draw flume or the culvert just below the flume. A second hole through the snow below the confluence showed water emerging from a culvert in the gravel slope east of the stream and 625 feet below the first hole (Figure 1). After analysis of field conditions, it was determined a tracer study at this site may confirm the hydrologic connection between the Daly Draw stream flow and the same observed rate of flow in the stream below the confluence in Empire Canyon. A Rhodamine WT dye tracer was ruled out, because of possible interference with subsequent studies, so a salt tracer study was conducted at this site.

The salt tracer study was accomplished with 1.5 pounds of table salt dissolved into 5 gallons of stream water. The salt solution was poured as a slug into the stream and the downstream site was monitored with a Horiba Water Quality Checker U-10 for the changes in specific conductivity values. The first arrival of the tracer occurred after 32 minutes, a peak was observed after 35 minutes, and the conductivity values returned to background levels within 60 minutes (Figure 2). Prior to the injection of the salt tracer, the pH was 7.7 and the water temperature was 2.1 degrees Celsius. Additional Phase I water data is shown in Tables 5a and 5b.

4.2 Rhodamine WT Dye.

In researching previous tracer studies that have been completed in an environment similar to the Empire Canyon project site, no available data were found prior to spring run-off and field activities. The majority of previous tracer studies have been completed in karst terrains. Research showed the tracer of choice and the quantity needed for a project was found to be dependent on specific site conditions and prior experience of those conducting the study.

The fluorescent dye tracer, Rhodamine WT, was chosen due to scheduling, availability of the dye, and the necessary equipment needed to analyze the samples. Rhodamine WT is a magenta colored dye that is sold as a 20% solution and has a specific gravity of 1.19 (Appendix A, Photo L5). Rhodamine WT quenches when it is mixed with chlorine, or when it is exposed to warm temperatures or environments with a pH less than 4. Rhodamine WT is visible to the eye down to approximately 100 parts per billion (ppb) and the EPA guidance is a maximum of 10 ppb at drinking water sources (EPA, 1986).

Rhodamine WT does not readily adsorb onto activated charcoal, therefore, the preferential method to analyze the samples is with a fluorometer (Aley and Fletcher, 1976). All samples were analyzed with a Turner Design Model 10 Series Filter Fluorometer, made available for this project through the Utah Division of Drinking Water. Periodic sampling and analysis with the fluorometer provided a comprehensive study of the dynamics of the hydrologic system of the streams. To differentiate between the dye and the natural fluorescence in the water due to organic material and other factors previously discussed, the background fluorescence level was established by collecting samples several days before and after the injection of dye into the stream. Calibration standards were determined as described in Fluorometric Procedures For Dye Tracing (Wilson and others, 1976) and are shown is Table 10.

The best professional estimate on the quantity of dye to use in the Phase I study varied from 50 ml to 250 ml (Aley, 2001). After considering the Phase I field conditions on May 7, a quantity of 250 ml was chosen for the site. The natural background fluorescence in Phase I was 0.007 ppb and a maximum dye concentration of 0.059 ppb was detected at the upstream sampling site (Upper Sampler).

Experience gained in Phase I provided useful data from which to determine the amount of dye to use in Phase II. In Phase II 750 ml of dye was injected resulting in higher concentrations detected at the sampling sites. The Phase II background fluorescence was 0.04 ppb and a maximum dye concentration of 20 ppb was detected at the upstream sample site (Ore-bin Pool). Tables 3 and 8 summarize the background and peak values for Phase I and Phase II, respectively.

5.0 DYE TRACER SAMPLE COLLECTION METHODS

All dye tracer water samples collected from the streams, seeps, and/or the springs were identified by location, date, and time. Water samples were promptly stored on ice and later analyzed in a random order with the fluorometer. Results of the dye trace analyses are shown in Tables 1 through 9 and Charts 1 through 13. Significant lapses of time within the frequency in which samples were collected are indicated in the charts with a space in the time line and as a data gap in the tables. The intervals at which the samples were collected were dependent on equipment performance, field work schedules and estimated dye travel time.

5.1 Manual Collection.

During the first hours of Phase I manual sample collection was conducted at the seeps and periodically thereafter for the duration of the study. Manual sampling at the seeps was deemed necessary due to three of the four seeps emerging from the base of the stream bank at or just above stream level and the lack of additional automated samplers. A total of 97 samples were collected at the seeps in Phase I, and 11 additional grab samples were collected at various locations and times (Tables 1 and 2, respectively). During Phase II, 15 grab samples were collected (Table 7).

5.2 Automated Sample Collection.

The majority of the samples collected during the dye tracer study were collected with Manning and ISCO samplers courtesy of the United States Geological Survey. The automated, self-contained units were powered by 12-volt batteries (Appendix A, Photos U8, U11, and U12). Samples were collected in midstream via a filtering probe on the end of a polyethylene tubing that extends from the sampling unit. The automated samplers were capable of collecting 24 samples at set intervals (a maximum of 12 hours) over several days. The sampling instruments generally performed well aside from wind interference and cold temperatures reducing the ability of the batteries to hold a charge.

The automated samplers collected 214 samples from three sites in Phase I and 302 samples from four sites in Phase II. (Tables 1 and 6, respectively).

6.0 PHASE I: DYE TRACER SAMPLING AND RESULTS.

The Phase I site area was located in the lower reaches of Walker-Webster Gulch and Empire Canyon as shown in Figure1. Phase I included collecting water samples to establish background fluorescence for two days prior to the injection of Rhodamine WT and sampling for 16 days after the event. The dye, Rhodamine WT, was injected into the stream at 14:05 on May 9 (Appendix A, Photo L5). The distance between the Phase I dye injection point and the most downstream sampling site was approximately 1,970 feet with a drop in elevation of approximately 200 feet. A total of 322 samples were collected between 11:15 on May 7 and 13:00 on May 24. The results from Phase I are shown in Tables 1 and 2, Charts 1 through 7, and summarized in Table 3. Water data collected during the study included pH, specific conductivity, temperature, and dissolved oxygen (Tables 5a and 5b).

The sampling sites were located in the stream upgradient from the iron gate, in the stream near Seep 4, in a pool upgradient from the municipal reservoir, and from four seeps adjacent to the stream (Appendix A, Photos L1 through L5). Between April 30 and May 9, before spring run-off, the seep sampling sites were established when surface water was observed in the stream channel and the Judge Tunnel was not turned out. Water flowed from the iron-gate seep in late April and early May, but appeared to be sensitive to early spring thaw and did not produce a significant quantity from which to sample later in the study.

On May 7 there was no flow through the Daly Draw, Empire Canyon, or Walker-Webster flumes; however, the iron-gate flume had water through it at approximately 90 gpm and the Judge Tunnel was not turned out (flume locations are shown in Figure 1). Stream flow increased in the Daly Draw flume, with a recorded peak of 780 gpm on May 14 and decreased to 201 gpm on the last day of the sampling, May 24. The Empire Canyon flume measured 300 gpm on May 14 and was dry on May 24. The Walker-Webster flume measured 552 gpm, 978 gpm, and 448 gpm for May 14, 18 and 24, respectively. Tables 4a and 4b provide additional flume measurement data including the observed occurrence of contributions to the stream channel from the Judge Tunnel. During the study, the maximum recorded flow rate through the iron gate flume was 2,822 gpm on May 18 .

At the time dye was injected into the system, the lower reaches of the stream in Walker-Webster Gulch were partially covered with snow. The stream channel was exposed at the Phase I dye injection point and visible through the snow on the discharge side of the first culvert. Beyond the first culvert, the stream disappeared under a snow bank, which covered the stream channel for approximately 50 feet along the north side of a mine building. The dye was injected into the stream just above the culvert in an attempt to provide a distance that would allow the stream to dilute the dye before it entered the snow bank and the subsurface.

By 15:00 on May 9, surface water flowed through the Walker-Webster flume at 63 gpm, and disappeared into the rocky stream channel 15 feet downgradient from the flume. The surface water exhibited a reddish hue through the flume for more than an hour after the dye was injected into the stream. In the first hours after the dye was injected, surface water in Walker-Webster Gulch and

Empire Canyon continued to increase marking the beginning of the spring run-off season. At 18:30 the surface water downstream of the Walker-Webster Gulch flume had not reached the second culvert at the confluence, which is approximately 600 feet downgradient of the dye injection point. By 21:15 on May 9, the Walker-Webster flume flow increased to 175 gpm, and less than 1 gpm was observed emerging from the second culvert. The Daly Draw and Empire Canyon flume measurements at 21:15 May 9 on were 422 gpm and 126 gpm, respectively.

6.1 Phase I: Automated Sampler Locations and Results.

The upstream, automated sampler site, Upper Sampler, was located on the downstream side of the first of three artificial pools located immediately upstream from the municipal reservoir. The Upper Sampler was the first downstream sample site at a distance of 1,040 feet from the dye injection point. At the Upper Sampler the first sample collected at 16:45 on May 9 had fluorescent levels five times that of background levels (Table 1, Chart 1). The dye levels detected from the Upper Sampler site decreased significantly from the onset and gradually returned to near background levels by 00:30 on May 12 as shown in Chart 1. A total of 63 samples were collected at the Upper Sampler location until 08:00 on May 18, at which time the flow decreased below sample collection limits and the stream was essentially dry.

The second automated sampler site, Middle Sampler, was located in the stream on a boulder above the first seep (Appendix A, Photo L1). The distance from dye injection point to the Middle Sampler location was approximately 1,750 feet. The Middle Sampler collected the first sample at 14:30 on May 9 and the results showed background fluorescence levels (Chart 2). The first sample indicating dye concentrations (fluorescence above background levels) was collected at 15:30 on May 9. Results from the Middle Sampler site showed dye concentrations peaked sometime before 19:35 on May 9 with concentration values five times that of background levels (Table 1, Chart 2). A return to near background fluorescent levels was detected in the sample collected at 5:50, May 11. A total of 47 samples were collected between 14:30 on May 9 and 13:00 on May 24.

The third automated sampler site, Lower Sampler, was located below the fourth seep and above the iron gate (Appendix A, Photo L4). The distance from the dye injection point to the Lower Sampler site was 1,970 feet. A total of 104 samples were collected at the Lower Sampler site between 11:15 on May 7 and 13:00 on May 24 (Table 1, Chart 3). A sample collection data gap exists between 12:00 and 18:00 on May 9 (Chart 3). Samples were collected hourly from 18:00 on May 9 through 15:00 on May 10. By 18:00 on May 9, a peak had already occurred at the sample site and dye concentration levels sharply decreased until 11:00 on May 10, at which time the fluorescence detected returned to near background levels.

6.2 Phase I: Seep Sample Locations and Results.

The first seep, Seep 1, was under a boulder in the stream at the Middle Sampler site location (Appendix A, Photo L1). A total of 19 grab samples were collected at Seep 1 during the first 15 hours of the study, after which the flow from the seep was indiscernible from the increased stream flow and the sampling of the seep was discontinued. The three lower seeps (Seep 2, 3, and 4) emerged from the west bank of the stream (Appendix A, Photos L2, L3, and L4). The flow from Seep 3 increased during the course of the study producing flow from several seeps within a few feet of the original seep. Seeps 2 and 4 emerged at stream level and also appeared to exhibit increased flows during the peak of spring run-off.

In the first 15 hours of Phase I, 11 to 15 samples were collected from each of the four seeps and their results indicated slight variations in the trends of flourescence detected (Table 1). Additional grab samples were collected at the seeps on May 14, 18, and 24. Results showed a declining trend from Seep 2 and 3, a slight increasing trend from Seep 1, and a few spikes from Seep 4 (Charts 4, 5, 6, and 7). Between 19:35 on May 9 and 4:45 on May 10 a small peak and decline was consistently detected in all the seeps, although less conclusively so with Seep 1, as only four samples were collected compared to seven from the other seeps. Spikes in the trend of the results may be attributed to contamination.

6.3 Phase I: Summary.

At 14:05 on May 9, dye was introduced to the stream above a dry Walker-Webster flume. Spring run-off began shortly after the dye was injected, producing 63 gpm through the Walker-Webster flume at 15:30; however, the water disappeared in the stream channel before it reached the second culvert 416 feet downstream. At the same time, 15:30 May 9, the first recorded appearance of dye downstream from the dye injection point occurred at the Middle Sampler and dye concentrations peaked between 16:00 and 19:35. The first sample was collected at the Upper Sampler site at 16:45. The results showed a peak had already occurred, which was followed by a sharp decline in concentrations until they reached background fluorescence levels. A continuous surface flow downstream to the second culvert occurred between 18:30 and 19:35. By 21:00, samples from the Upper Sampler indicated dye concentrations had declined and the observed discharge from the second culvert (upgradient) was less than 1 gpm.

The level of fluorescence detected from the seeps did not rise significantly above background during the study compared to the stream, which showed an obvious change in the trend of the dye concentration. This indicates the source of the seep water is not from the adjacent stream, and there is not a strong indication that a direct hydrologic connection exists between the dye injection point and the seeps. Although there is a slight downward trend in the results from Seeps 2 and 3, which may parallel the trend from the stream for the same time period, there was either no background data or an adequate number of samples collected after May 10 from which to conclusively establish a hydrologic connection to the dye injection point. This may be attributed to the tracer medium (greater dispersion or adsorption) whereas a different dye and/or a larger quantity of dye may have produced more significant results. A summary of the data from Phase I is shown in Table 3.

The water data indicate the source of the seeps is not the adjacent stream. The water data from Phase I showed the specific conductivity was generally higher in the seeps, in the upper Empire Canyon reaches, and at the mouth of Walker-Webster Gulch than in the lower reaches of Empire Canyon or in the Daly Draw stream. The pH was generally slightly lower in the seeps than in the streams.

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7.0 PHASE II: DYE TRACER SAMPLING AND RESULTS.

The Phase II site area is located in the upper reaches of Walker-Webster Gulch near the McConkie ski lift (Figure 1). At 17:45 on June 7, 750 ml of dye was poured into the stream 750 feet upgradient from the first sampling site (Appendix A, Photo U1). By 20:00 on June 7, no visible dye was observed at the Phase II dye injection point. The distance from the Phase II dye injection point to the lowest sampling site was 3,040 feet with a drop in elevation of 380 feet. A total of 317 samples were collected between 11:30 on June 1 and 13:05 on July 2, as shown in Table 6. Fifteen of the 317 samples collected were grab samples collected at various locations between June 7 and June 22 (Table 7). The results from Phase II are shown in Charts 8 through 13, and summarized in Table 8. Water data collected during Phase II included pH, conductivity, temperature, and dissolved oxygen as shown in Table 9.

Several possible sampling locations were identified; however, due to field schedules and the number of available automated samplers, the sample locations were limited to four initial sites. Primary sampling sites downgradient of the Phase II dye injection point, respectively, were the Ore-bin Pool, the White Pipe, the spring at the toe of the mine tailings (TOE), and the seeps at the Power Pole. Secondary sampling sites included the pool between the TOE and the Power Pole (½-Pool), and from the pool in the stream adjacent to the Power Pole site (P-str).

In the lower reaches of Walker-Webster Gulch the flow through the flume decreased from 85 gpm on June 4 to 40 gpm on June 7. During a field visit on June 1 and 4, the stream channel above the Ore-bin Pool was partially covered with snow and where it was exposed, no surface water was observed. When the dye was injected on June 7, water flowed from the White Pipe and was barely discernable between the cobbles in the stream channel downstream to the TOE site and spring, which produced an estimated 300-400 gpm. On June 7 ground water was observed emerging from the seeps on the east bank near the ½-Pool (above the Power Pole sample site) and from the seeps at the Power Pole. Downgradient of the Power Pole site, the gulch continues to the northeast and the stream channel was dry until the point where the gulch curves to the east. Surface water was observed at this bend and then disappeared approximately 100 feet upstream from the Phase I dye injection point and near the confluence with Empire Canyon. The occurrence of intermittent surface flow in Walker-Webster Gulch was consistent throughout Phase II until late in the study, at which time flows decreased and receded upstream as spring run off ceased.

7.1 Phase II: Automated Sampler Locations and Results.

The first sampling site downgradient of the Phase II dye injection point, Ore-bin Pool, was east of the McConkie ski lift in a pool at the mouth of a narrow, pine-shaded drainage as shown in Appendix A Photos U1 and U2. An automated sampler was placed on logs along the side of the pool. A total of 43 water samples were collected from the Ore-bin Pool site between 14:30 on June 7 and 12:40 on July 2. The peak dye concentration detected in the Ore-bin Pool samples occurred at 11:25 on June 8 (Chart 8). Automated sampling was discontinued at the Ore-bin Pool site after a windstorm on June 12 blew a tree over hitting the sampler. The results of the grab samples collected at the Ore-bin Pool site after June 12 indicate fluorescence levels were returning to background levels (Table 7, Chart 8). Within the same time period, grab samples collected from the spring opposite the ore bin (and above the Ore-bin Pool) were of similar concentrations to those taken from the Ore-bin Pool site and higher than those taken from the stream adjacent to the spring. The overflow from the Ore-bin Pool site disappeared into the ground before entering a culvert adjacent to the ski lift. The other end of the culvert emerges from an embankment 550 feet downgradient of the Ore-bin Pool site (near the spring at the aspen tree) and 80 feet lower in elevation. No discharge from the culvert was observed during the study (Appendix A, Photo U4).

Photo U4 in Appendix A shows the drier reach of the stream channel and the location of a spring found at the base of an aspen tree. The aspen spring was flowing at 1 to 2 gpm on June 4 and was not observed to flow again during the study. In the background of Photo U4 is the McConkie ski lift on an embankment constructed for the ski run. The dry flat below the McConkie lift is at the top of the capped mine waste shown in Photos U6 and U7. The stream channel around the mine tailings and downgradient to the lowest Phase II sample site was reconstructed with a poly-liner, fine sediment, and/or rip-wrap (Appendix A, Photos U5 through U16).

A white pipe shown in Photos U5 and U6 emerges from the ground 1,068 feet downgradient from the Phase II dye injection point and west of the general trend of Walker-Webster Gulch. The white pipe is connected to an underground water storage tank that was historically used in the immediate area before the Park City municipal water system was piped up the mountain (Gee, 2001). The historical water supply system was connected to several springs in Walker-Webster Gulch watershed and sections of piping are still visible above the Ore-bin Pool site. Water consistently flowed from the white pipe for the duration of the study at approximately 6 gpm, and disappeared in the reconstructed stream channel 20 feet downstream (Appendix A, Photo U15). Dye was first detected at the White Pipe sample site in the sample collected at 14:40 on June 9, and the results showed a peak occurred at 02:40 on June 11. A return to background fluorescence levels occurred at 11:25 on June 25 (Chart 9). The last White Pipe sample was collected at 12:50 on July 2.

Samples from TOE site were collected between June 1 and June 16, at which time the spring near the site ceased to flow (Appendix A, Photos U14 and U15). The TOE samples showed a steady trend in background levels between June 1 and June 7 as shown in Chart 10. Dye was detected at the TOE site at 18:20 on June 8 and sampling results show a peak occurred after 18:10 on June 11. On June 14, flow from the spring had significantly decreased, requiring a hole to be dug to deepen the pool for the sampling probe, while at the same time the flow in the channel near the Power Pole had decreased only slightly. The TOE site sampling results showed decreasing dye concentrations; however, the spring ceased before fluorescence levels returned to background levels. The last sample from the TOE site was taken at 14:40 on June 16, at which time the sampler was moved to the ½-Pool sample site (located halfway between the TOE and the Power Pole sites). The concentrations of dye detected from the TOE site were less than the concentrations from the Ore-bin Pool, but significantly higher than the concentrations from the White Pipe site (Charts 8, 9, and 10).

The ½-Pool sampling site, was located approximately half-way between the TOE and the Power Pole sites. Three seep sites were identified near the ½-Pool site (Photos U8, U9, and U10). After the spring near the TOE site dried up, the ½-Pool was sampled for two days, at which time the water level in the pool dropped below the sampling probe. The last ½-Pool sample was taken at 16:15 on June 18 (Table 6 and Chart 11). On June 19, the seeps near the ½-Pool were dry and the stream emerged 8 feet downstream from the ½-Pool, but disappeared again adjacent to the power pole

(Appendix A, Photos U11, U12, U13). The stream reach adjacent to the power pole was noticeably green with algae on June 19.

The most downgradient Phase II sampling sites collected samples from two pools near a power pole (Appendix A, Photo U13). Samples were collected from a pool in the stream, the P-str site, immediately downgradient of the power pole between June 1 and June 7 (Chart 13). On June 7, following the injection of dye the automated sampler was moved to the upstream side of the power pole to collect samples from a small pool dug out to collect water from a seepage area (Power Pole site) on the west bank of the stream (Appendix A, Photo U11). On the June 19 field visit, the TOE, ½-Pool, and P-str sampling sites were dry and the flow of water from the seeps at the Power Pole site was significantly reduced, so the automated sampler was removed (Appendix A, Photos U11, U12, and U13). Three additional grab samples were collected from the Power Pole site on June 25, 28, and July 2 (Chart 12).

7.2 Phase II: Summary.

At 17:45 on June 7, 750 ml of dye was poured into the stream channel in the upper reaches of Walker-Webster Gulch. The first appearance of the dye occurred at the Ore-bin Pool site and concentrations peaked before dye appeared downstream at the TOE site. The White Pipe site's first dye appearance occurred after dye appeared at the TOE site and the results showed a peak shortly after the TOE site peaked. Furthermore, the concentration of dye detected was significantly higher from the TOE site than from the White Pipe site. These results indicate a direct hydrologic connection between the Phase II dye injection point, the TOE, and White Pipe sites.

The times and dates of the appearance of dye and the peak dye concentrations detected from the sample sites appear to indicate the dye tracer moved systematically downgradient. After the TOE dried up the ½-Pool concentrations were approximately half those of the last TOE samples and the Power Pole concentrations were half those of the ½-Pool samples. The distance between the TOE, ½-Pool, and Power Pole sites may explain the incremental differences in the concentrations of the samples. However, the fluorescence detected from the Power Pole site remained low during the study until after the other sample sites returned to background levels, at which time the Power Pole fluorescence levels gradually increased. This increased level of fluorescence detected in samples collected from the Power Pole site may indicate a delayed response to the dye through the system or, more probably, indicates there is no connection between the seeps and the Phase II dye injection point and the increased fluorescence is attributed to natural fluorescence of the water. An increase in the natural fluorescence may be associated with observed warming (summer) temperatures and the accumulation of algae on the rocks in the stream that produced a green tint to the water.

8.0 CONCLUSIONS.

8.1 Phase I: Conclusions.

In April, water was observed in the stream channel downstream from the Seep 1 site. Upstream, the only observed surface water (other than that from the Judge Tunnel) appeared under the snow above the Daly Draw flume. A salt tracer study was completed and showed a hydrologic connection between the stream above the Daly Draw flume and the discharge from a culvert at the Empire Canyon confluence.

On May 7, a dye tracer was injected above the Walker-Webster flume. Spring run-off started within the hour following the injection of the dye and surface flow gradually increased downstream over the next 24 hours. While the concentrations of dye detected at the sampling sites are low, the recovery curves in Charts 1 through 7 show trends that would be expected from a tracer injection.

The Phase I dye trace showed a subsurface hydrologic connection between the dye injection point and the stream channel below the unconsolidated material at the mouth of Walker-Webster Gulch. Phase I also indicated a direct subsurface hydrologic connection between the dye injection point and the Middle Sampler site, which is 1,750 feet downstream. Phase I did not conclusively show a hydrologic connection between the dye injection point and the Seep sites. However, Phase I did indicate the source of the seeps is not from the adjacent stream and may be connected to ground water sources upgradient of the seeps. The variance in the specific conductivity and pH measurements also indicates the seep source(s) is influenced by a source other than the adjacent stream such as the adjacent slope covered with mine tailings. Future studies may consider (1) using a larger quantity of dye to better ascertain the ground water pathway and improve dye recovery, (2) sampling several strategic sites below the second culvert to ascertain at what point(s) water enters the Empire Canyon stream channel, and (3) conducting more extensive sampling at the Seep sites, including monitoring for a longer period of time (before and after dye injection).

8.2 Phase II: Conclusions.

The last sample of Phase I was collected on May 24 and Phase II sampling began eight days later on June 1. As the water in the stream channel in the Phase I site area decreased and the flumes were nearly dry, the water receded upstream within the Phase II site area. At the start of Phase II, the spring near the TOE sampling site produced 300-400 gpm and significantly less surface flow was observed adjacent to the power pole. Phase II results showed that a hydrologic connection exists between the dye injection point and the spring at the toe of the mine waste. Although a lower concentration of dye was detected at the White Pipe site, a hydrologic connection also exists between it and the dye injection point. It is less apparent that a hydrologic connection exists between the seeps at the Power Pole site and the dye injection point. Similar to Phase I, Phase II showed the source of the seeps at the Power Pole site is probably not from the adjacent stream. Future tracer studies in the Phase II site area may include more extensive work, including a longer monitoring period (before and after dye injection), and a larger quantity of dye injected to ascertain the source of the seeps at the Power Pole downstream from the spring at the toe of the mine waste.

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FIGURES

Color Map(s)

The following pages contain color that does not appear in the scanned images.

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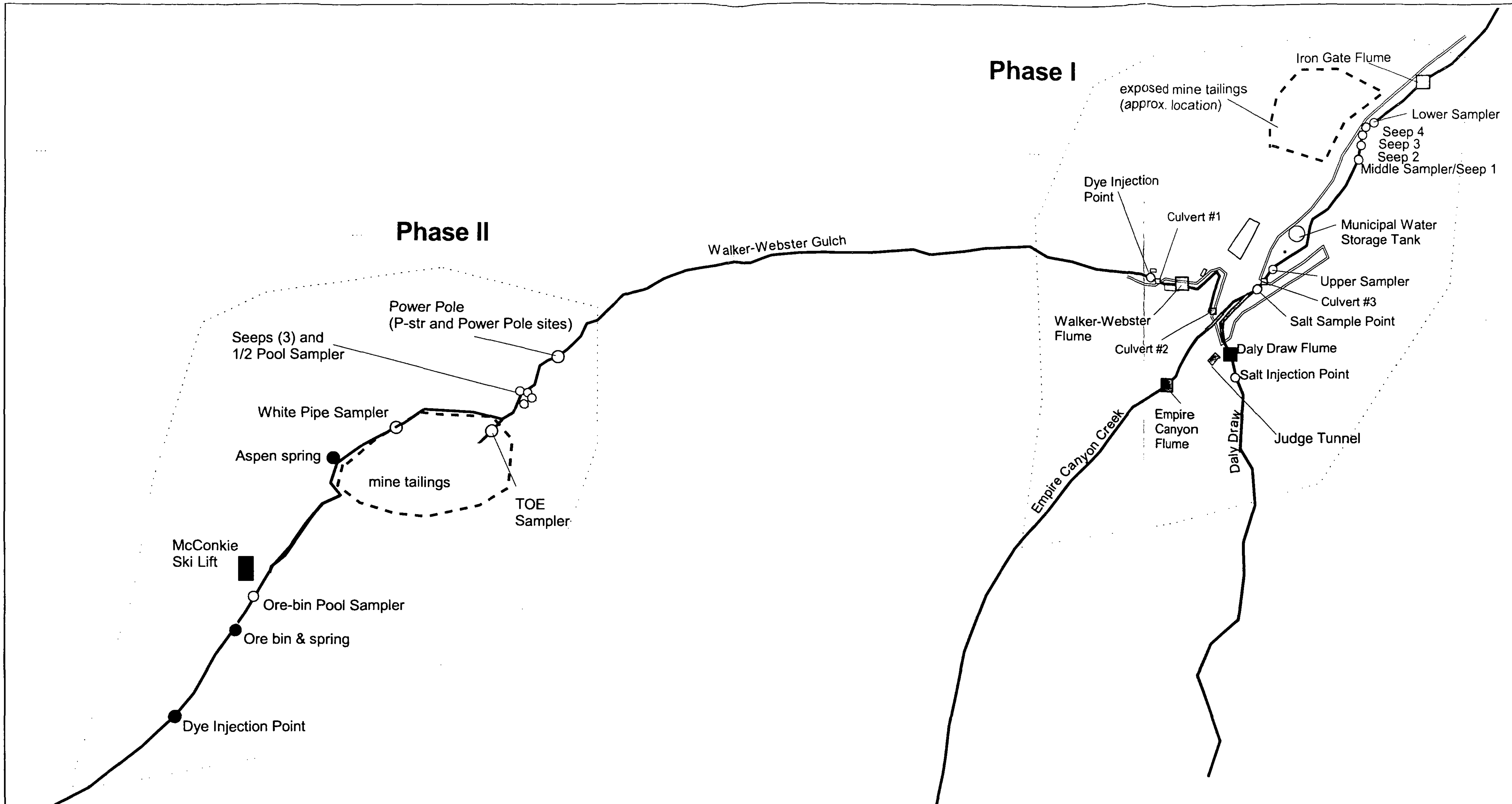


250 0 250 500 750 1000 1250 Feet

By: AMT Date: December 6, 2001 (tracer 2)

Site Location

N

Legend

- Salt Tracer sites
- Seep sites
- Springs
- Dye introduction point
- Sampler sites
- Buildings
- Flumes
- Culvert
- Streams
- Dirt Road
- Extended underground culvert

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY

Utah Department of Environmental Quality
Division of Environmental Response and Remediation

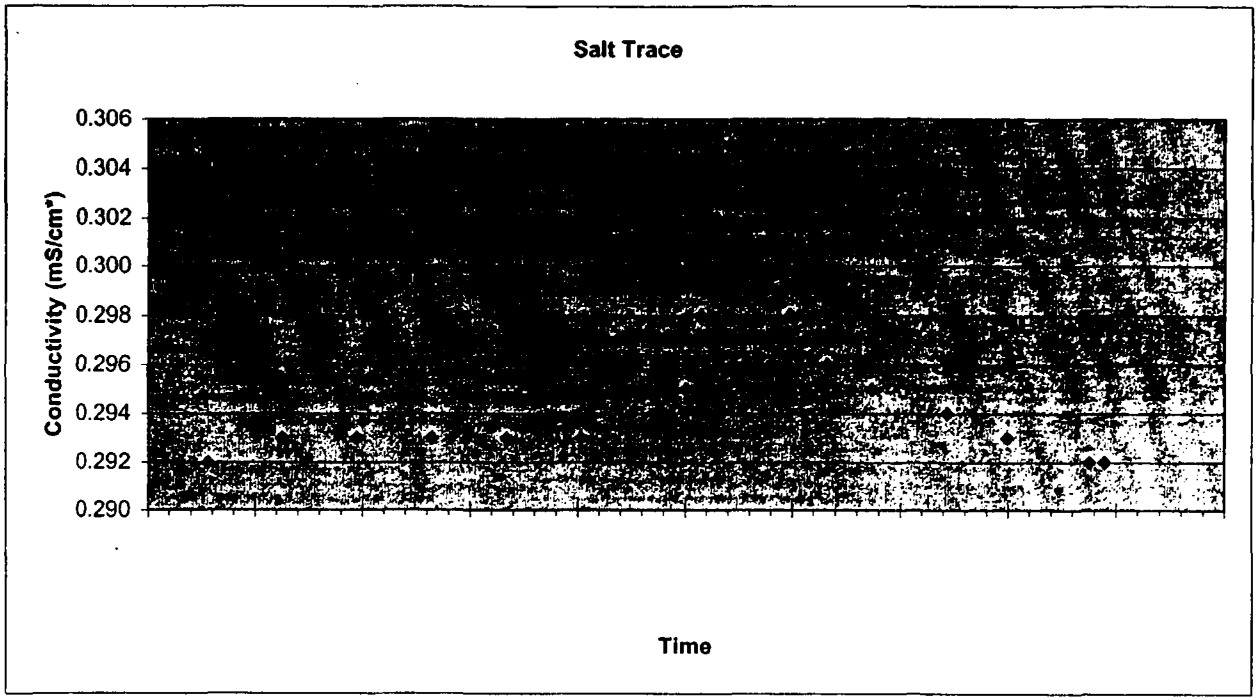
Figure 1
Site Location Map
Tracer Study Results Report

Empire Canyon ESI, Park City, Utah

Figure 2. Salt Trace Study Data, April 30, 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

Time	Conductivity (mS/cm*)
15:40:00	0.292
15:45:00	0.293
15:50:00	0.293
15:55:00	0.293
16:00:00	0.293
16:05:00	0.293
16:12:00	0.295
16:13:00	0.298
16:14:00	0.302
16:15:00	0.305
16:15:30	0.304
16:16:00	0.303
16:17:00	0.301
16:17:30	0.300
16:18:00	0.299
16:19:00	0.298
16:20:00	0.297
16:21:30	0.296
16:24:30	0.295
16:29:30	0.294
16:33:30	0.293
16:39:00	0.292
16:40:00	0.292

*mS/cm: milli-Siemens/centimeter.



Injection point to:	*Distance (feet)**
flume	121
culvert intake	151
culvert outflow	605
sample location	625

* Distances measured by hip chain.

TABLES

Table 1. Phase I: Seep and Automated Sampler Results, May 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)						
Location	Sample Date	Time	x100xmin	x100x3.16	x100x10	x100x31.6	Bottle type	Lab Date	Notes
SEEP 1	9-May	14:05	0.1	0.2	0.6	2	br 40 ml vial	lab 5/16	
1	9-May	14:15	0.1	0.2	0.55	1.8	br 40ml*	lab 5/17p	
1	9-May	14:25	0.1	0.15	0.55	1.7	br 40ml*	lab 5/17p	
1	9-May	14:35	0.1	0.15	0.55	1.95	br 40ml*	lab 5/17p	
1	9-May	14:45	0.1	0.15	0.6	2	br 40 ml vial	lab 5/16	
1	9-May	14:55	0.1	0.2	0.6	1.9	br 40ml*	lab 5/17p	
1	9-May	15:05	0.1	0.2	0.55	1.95	br 40ml*	lab 5/17p	
1	9-May	15:15	0.1	0.2	0.55	1.9	br 40ml*	lab 5/17p	
1	9-May	15:25	0.1	0.2	0.6	1.9	lots of floates	lab 5/17p	
1	9-May	15:35	0.1	0.15	0.5	1.9	br 40 ml vial	lab 5/16	
1	9-May	15:45	0.1	0.2	0.55	1.9	br 40 ml vial	lab 5/16	
1	9-May	15:55	0.1	0.2	0.55	1.9	br 40 ml vial	lab 5/16	
1	9-May	16:05	0.1	0.25	0.75	2.7	br40ml	lab5/25	*variance.2
1	9-May	16:15	0.1	0.2	0.7	2.1	br 40 ml vial	lab 5/16	
1	9-May	16:45	0.1	0.2	0.75	2.6	br 40ml*	lab 5/17p	
(data gap)									
1	9-May	19:38	0.1	0.2	0.7	2.3	cl 40ml	lab 5/16	
(data gap)									
1	10-May	0:25	0.1	0.2	0.6	2.1	cl 40ml	lab 5/16	var .4
1	10-May	2:00	0.1	0.2	0.65	2.1	40ml vial	lab 5/16	
1	10-May	4:45	0.1	0.2	0.65	2.1	40ml vial	lab 5/16	
(data gap)									
1	24-May	13:00	0.15	0.3	1	3.3	cl40ml	lab5/25	**
SEEP 2	9-May	14:07	0.15	0.3	0.95	3.1	cl40ml	lab5/25	*
2	9-May	14:15	0.1	0.2	0.7	2.2	cl40ml	lab5/25	*
2	9-May	14:16	0.1	0.2	0.7	2.3	cl40ml	lab5/25	*
2	9-May	14:25	0.1	0.2	0.7	2.2	cl40ml	lab5/25	*
2	9-May	14:35	0.1	0.2	0.75	2.6	cl40ml	lab5/25	*,cuvette s. level low
2	9-May	14:45	0.15	0.2	0.65	2.1	cl 40ml	lab 5/25	v.2
2	9-May	14:55	0.1	0.2	0.7	2.3	cl 40ml	lab 5/25	v.2
2	9-May	15:07	0.1	0.2	0.65	2.2	cl 40ml	lab 5/25	
2	9-May	15:15	0.1	0.2	0.7	2.2	cl 40ml	lab 5/25	
2	9-May	15:25	0.1	0.2	0.65	2.2	cl 40ml	lab 5/25	
2	9-May	15:35	0.1	0.2	0.6	2.1	cl 40ml	lab 5/25	*v.2
2	9-May	15:45	0.1	0.2	0.65	2.2	cl 40ml	lab 5/25	v.2

Table 1. Phase I: Seep and Automated Sampler Results, May 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)						
Location	Sample Date	Time	x100xmin	x100x3.16	x100x10	x100x31.6	Bottle type	Lab Date	Notes
2	9-May	15:55	0.1	0.2	0.7	2.5	cl 40ml	lab 5/25	v.2
2	9-May	16:07	0.1	0.2	0.55	1.8	cl 40ml	lab 5/17p	
2	9-May	16:15	0.1	0.15	0.5	1.9	cl 40ml	lab 5/17p	
2	9-May	16:48	0.1	0.15	0.6	1.9	cl 40ml	lab 5/16	
(data gap)									
2	9-May	19:37	0.1	0.15	0.55	1.9	cl 40ml	lab 5/16	
2	9-May	20:55	0.1	0.15	0.55	1.8	cl 40ml	lab 5/16	
2	9-May	22:25	0.1	0.2	0.75	2.5	cl 40ml	lab 5/16	var .15
2	9-May	23:25	0.05	0.2	0.7	2.3	cl 40ml	lab 5/16	var .1
2	10-May	0:25	0.05	0.15	0.55	2.1	cl 40ml	lab 5/16	
2	10-May	2:00	0.1	0.15	0.6	1.9	40ml vial	lab 5/16	
2	10-May	4:45	0.1	0.2	0.55	1.9	500ml bottle	lab 5/16	
(data gap)									
2	10-May	17:45	0.1	0.2	0.6	2	40ml vial	lab 5/15	
(data gap)									
2	14-May	16:30	0.1	0.15	0.6	1.9	cl 40ml*	lab 5/17p	
(data gap)									
2	18-May	13:30	0.1	0.2	0.8	2.3	1000ml	lab5/25	
(data gap)									
2	24-May	13:00	0.1	0.2	0.7	2.4	br40ml	lab5/25	**
SEEP 3	9-May	14:46	0.15	0.25	0.9	3	cl 40ml	lab 5/25	
3	9-May	14:56	0.1	0.25	0.8	2.5	cl 40ml	lab 5/25	
3	9-May	15:06	0.1	0.2	0.7	2.3	cl40ml	lab5/25	*
3	9-May	15:16	0.1	0.2	0.7	2.3	cl40ml	lab5/25	*
3	9-May	15:26	0.1	0.25	0.65	2.2	cl 40ml	lab 5/25	
3	9-May	15:36	0.1	0.2	0.75	2.4	cl 40ml	lab 5/25	
3	9-May	15:46	0.1	0.2	0.7	2.3	cl40ml	lab5/25	*
3	9-May	15:56	0.1	0.2	0.75	2.3	cl 40ml	lab 5/25	
3	9-May	16:08	0.1	0.2	0.75	2.3	cl40ml	lab5/25	*
3	9-May	16:50	0.1	0.2	0.7	2.2	cl 40ml	lab 5/16	
3	9-May	19:36	0.1	0.2	0.6	2	cl 40ml	lab 5/16	
3	9-May	20:53	0.05	0.15	0.65	2	cl 40ml	lab 5/16	
3	9-May	22:25	0.1	0.2	0.7	2.4	cl 40ml	lab 5/16	var .2
3	9-May	23:25	0.1	0.2	0.7	2.3	cl 40ml	lab 5/16	var .15
3	10-May	0:25	0.05	0.2	0.7	2.2	40ml vial	lab 5/16	
3	10-May	2:00	0.1	0.2	0.7	2.2	cl 40ml	lab 5/16	
3	10-May	4:45	0.1	0.2	0.65	2.15	40ml vial	lab 5/16	
(data gap)									
3	10-May	17:45	0.1	0.2	0.7	2.2	500ml bottle	lab 5/15	
(data gap)									

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			Fluorometer (relative fluorescence units)						
Location	Sample Date	Time	x100xmin	x100x3.16	x100x10	x100x31.6	Bottle type	Lab Date	Notes
3	14-May	16:30	0.1	0.2	0.65	2.1	cl 40ml*	lab 5/17p	
3	14-May	16:33	0.1	0.2	0.7	2.1	cl 40ml*	lab 5/17p	
3	14-May	16:36	0.1	0.2	0.65	2.1	cl 40ml*	lab 5/17p	
3	14-May	20:00	0.1	0.25	0.8	2.5	500ml bottle	lab5/25	*
3	14-May	20:05	0.1	0.2	0.8	2.6	500ml bottle	lab5/25	*
(data gap)									
3	18-May	13:35	0.1	0.2	0.7	2.5	1000ml	lab5/25	
3	18-May	13:30	0.1	0.2	0.8	2.4	1000ml	lab5/25	
(data gap)									
3	24-May	13:00	0.1	0.2	0.8	2.5	cl40ml	lab5/25	**
SEEP 4	9-May	14:15	0.1	0.2	0.7	2.3	cl40ml	lab5/25	*
4	9-May	14:25	0.1	0.2	0.75	2.2	cl40ml	lab5/25	*v.2
4	9-May	14:35	0.1	0.2	0.75	2.2	cl40ml	lab5/25	*v.2
4	9-May	14:47	0.1	0.2	0.7	2.2	cl40ml	lab5/25	*v.2
4	9-May	14:58	0.1	0.2	0.7	2.3	cl40ml	lab5/25	*
4	9-May	15:05	0.15	0.3	1.1	3.5	cl40ml	lab5/25	*v.2
4	9-May	15:15	0.1	0.2	0.65	2	40ml vial	lab 5/16	
4	9-May	15:26	0.1	0.2	0.6	2	40ml vial	lab 5/16	
4	9-May	15:35	0.1	0.2	0.6	2	40ml vial	lab 5/16	
4	9-May	15:45	0.1	0.15	0.55	2	40ml vial	lab 5/16	
4	9-May	15:55	0.05	0.15	0.6	2	40ml vial	lab 5/16	
4	9-May	16:50	0.1	0.25	1.05	3.6	40ml vial	lab 5/16	
(data gap)									
4	9-May	19:35	0.1	0.15	0.6	2	cl 40ml	lab 5/16	
4	9-May	20:50	0.1	0.25	0.85	2.8	cl 40ml	lab 5/16	
4	9-May	22:25	0.1	0.2	0.75	2.3	cl 40ml	lab 5/16	var .15
4	9-May	23:00	0.1	0.2	0.7	2.3	cl 40ml	lab 5/16	var .1
4	10-May	0:25	0.1	0.2	0.7	2.3	40ml vial	lab 5/16	
4	10-May	2:00	0.05	0.3	0.65	2.2	cl 40ml	lab 5/16	
4	10-May	4:45	0.1	0.25	0.7	2.3	40ml vial	lab 5/16	
(data gap)									
4	10-May	17:45	0.1	0.2	0.7	2.2	500ml bottle	lab 5/15	
(data gap)									
4	14-May	16:30	0.1	0.2	0.7	2.2	cl 40ml*	lab 5/17p	
4	14-May	19:55	0.1	0.2	0.75	2.5	500ml bottle	lab5/25	*
(data gap)									
4	18-May	13:30	0.1	0.2	0.75	2.4	1000ml	lab5/25	
(data gap)									
4	24-May	13:00	0.1	0.2	0.75	2.5	br40ml	lab5/25	**

Table 1. Phase I: Seep and Automated Sampler Results, May 2001
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UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)						
Location	Sample Date	Time	x100xmin	x100x3.16	x100x10	x100x31.6	Bottle type	Lab Date	Notes
Lower	7-May	11:15	0.1	0.2	0.8	2.9	100ml bottle	lab 5/15	
Sampler	7-May	11:45	0.1	0.2	0.7	2.3	100ml bottle	lab 5/15	
LS	7-May	12:15	0.1	0.2	0.7	2	100ml bottle	lab 5/15	
LS	7-May	12:45	0.05	0.15	0.6	1.9	100ml bottle	lab 5/15	
LS	7-May	13:15	0.05	0.2	0.6	1.9	100ml bottle	lab 5/15	
LS	7-May	13:45	0.1	0.15	0.5	1.9	100ml bottle	lab 5/15	
LS	7-May	14:15	0.1	0.2	0.6	1.9	100ml bottle	lab 5/15	
LS	7-May	14:45	0.1	0.2	0.6	2	100ml bottle	lab 5/15	
LS	7-May	15:15	0.1	0.2	0.6	1.9	100ml bottle	lab 5/15	
LS	7-May	16:00	0.1	0.2	0.7	2.4	100ml bottle	lab 5/15	
LS	7-May	20:00	0.1	0.2	0.6	2.2	100ml bottle	lab 5/15	
LS	7-May	24:00:00	0.1	0.2	0.6	2.1	100ml bottle	lab 5/15	
LS	8-May	4:00	0.1	0.2	0.7	2.4	100ml bottle	lab 5/16	
LS	8-May	8:00	0.1	0.2	0.7	2.4	100ml bottle	lab 5/15	
LS	8-May	12:00	0	0.2	0.6	2	100ml bottle	lab 5/15	
LS	8-May	16:00	0.1	0.2	0.6	2.1	100ml bottle	lab 5/15	
LS	8-May	20:00	0.1	0.2	0.7	2.5	100ml bottle	lab 5/15	
LS	9-May	0:00					Lab opps: diluted	lab 5/15	
LS	9-May	4:00	0.1	0.2	0.7	2.3	100ml bottle	lab 5/15	
LS	9-May	8:00	0.1	0.2	0.7	2.2	100ml bottle	lab 5/15	
LS	9-May	12:00	0.1	0.2	0.7	2.4	100ml bottle	lab 5/15	
(data gap)									
LS	9-May	18:00	0.4	1	3.3	10	100ml bottle	lab 5/15	
LS	9-May	19:00	0.25	0.8	2.9	9	500ml bottle	lab 5/15	
LS	9-May	20:00	0.3	0.7	2.3	7.2	500ml bottle	lab 5/15	
LS	9-May	21:00	0.2	0.6	2.1	6.8	500ml bottle	lab 5/15	
LS	9-May	22:00	0.2	0.6	1.9	6.2	500ml bottle	lab 5/15	
LS	9-May	23:00	0.2	0.5	1.8	5.6	500ml bottle	lab 5/15	
LS	10-May	0:00:00	0.2	0.5	1.7	5.4	500ml bottle	lab 5/15	
LS	10-May	1:00	0.15	0.45	1.5	4.9	500ml bottle	lab 5/15	
LS	10-May	2:00	0.2	0.45	1.5	4.9	500ml bottle	lab 5/15	
LS	10-May	3:00	0.2	0.5	1.5	4.9	500ml bottle	lab 5/15	
LS	10-May	4:00	0.15	0.4	1.4	4.4	500ml bottle	lab 5/15	
LS	10-May	5:00	0.2	0.4	1.4	4.4	500ml bottle	lab 5/15	
LS	10-May	6:00	0.2	0.4	1.3	4	500ml bottle	lab 5/15	
LS	10-May	7:00	0.15	0.4	1.3	4	500ml bottle	lab 5/15	
LS	10-May	8:00	0.15	0.4	1.2	3.8	500ml bottle	lab 5/15	
LS	10-May	9:00	0.15	0.4	1.1	3.9	500ml bottle	lab 5/15	
LS	10-May	10:00	0.1	0.45	1.5	3.9	500ml bottle	lab 5/15	
LS	10-May	11:00	0.1	0.2	0.8	2.6	500ml bottle	lab 5/15	
LS	10-May	12:00	0.1	0.3	0.8	2.7	500ml bottle	lab 5/15	
LS	10-May	13:00	0.1	0.25	0.9	2.8	500ml bottle	lab 5/15	

Table 1. Phase I: Seep and Automated Sampler Results, May 2001
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UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)						
Location	Sample Date	Time	x100xmin	x100x3.16	x100x10	x100x31.6	Bottle type	Lab Date	Notes
LS	10-May	14:00	0.1	0.25	0.9	2.7	500ml bottle	lab 5/15	
(data gap)									
LS	10-May	15:00	0.1	0.3	1	3.1	500ml bottle	lab 5/15	
LS	10-May	17:00	0.15	0.3	1.1	3.4	cl 40 ml ** v.2	lab 5/17 p	
(data gap)									
LS	10-May	21:00	0.15	0.3	1	3.2	cl 40ml*	lab 5/17p	
LS	11-May	1:00	0.1	0.25	0.9	3	cl 40ml*	lab 5/17p	
LS	11-May	5:00	0.1	0.2	0.75	2.6	cl 40ml*	lab 5/17p	
LS	11-May	9:00	0.1	0.2	0.75	2.55	cl 40ml*	lab 5/17p	
LS	11-May	13:00	0.1	0.2	0.75	2.55	cl 40ml*	lab 5/17p	
LS	11-May	17:00	0.1	0.2	0.8	2.8	cl 40ml*	lab 5/17p	
LS	11-May	21:00	0.1	0.25	0.9	2.8	cl 40ml*	lab 5/17p	
LS	12-May	1:00	0.1	0.25	0.9	2.8	cl 40ml* v.2	lab 5/16	
LS	12-May	5:00	0.1	0.25	0.8	2.6	cl 40ml v.2	lab 5/16	
LS	12-May	9:00	0.1	0.25	0.8	2.6	cl 40ml v.2	lab 5/16	
LS	12-May	13:00	0.1	0.2	0.75	2.5	cl 40ml v.2	lab 5/16	
LS	12-May	17:00	0.1	0.2	0.8	2.8	cl 40ml v.2	lab 5/16	
LS	12-May	21:00	0.1	0.2	0.9	2.8	cl 40ml v.2	lab 5/16	
LS	13-May	1:00	0.1	0.25	0.9	2.8	cl 40ml v.2	lab 5/16	
LS	13-May	5:00	0.1	0.25	0.8	2.6	cl 40ml v.2	lab 5/16	
LS	13-May	9:00	0.1	0.25	0.8	2.6	cl 40ml v.2	lab 5/16	
LS	13-May	13:00	0.1	0.2	0.75	2.6	cl 40ml v.2	lab 5/16	
LS	13-May	17:00	0.1	0.2	0.8	2.6	cl 40ml v.2	lab 5/16	
LS	13-May	21:00	0.1	0.2	0.9	2.6	cl 40ml v.2	lab 5/16	
LS	14-May	1:00	0.1	0.25	0.9	2.6	cl 40ml v.2	lab 5/16	
(data gap)									
LS	14-May	19:15	0.15	0.25	0.9	2.9	br 100ml	lab5/25	
LS	14-May	23:15	0.1	0.25	0.9	2.7	br 100ml	5/30	
LS	15-May	3:15	0.15	0.3	0.9	2.9	br 100ml	5/30	
LS	15-May	7:15	0.1	0.2	0.85	2.8	br 100ml	5/30	
LS	15-May	11:15	0.1	0.25	0.8	2.7	br 100ml	5/30	
LS	15-May	15:15	0.15	0.3	1.05	3.1	br 100ml	lab5/25	
LS	15-May	19:15	0.15	0.25	0.9	2.9	br 100ml	5/30	fewer flts
LS	15-May	23:15	0.1	0.25	0.8	2.8	br 100ml	5/30	
LS	16-May	3:15	0.1	0.3	0.8	2.9	br 100ml	5/30	fewer flts
LS	16-May	7:15	0.1	0.3	0.9	2.9	br 100ml	5/30	fewer flts
LS	16-May	11:15	0.1	0.25	0.85	2.7	br 100ml	5/30	fewer flts
LS	16-May	15:15	0.1	0.3	0.9	3.1	br 100ml	5/30	fewer flts
LS	16-May	19:15	0.1	0.3	0.9	2.9	br 100ml	5/30	
LS	16-May	23:15	0.1	0.25	0.95	2.8	br 100ml	5/30	
LS	17-May	3:15	0.15	0.25	0.8	2.8	br 100ml	5/30	
LS	17-May	7:15	0.15	0.25	0.85	2.7	br 100ml	5/30	

Table 1. Phase I: Seep and Automated Sampler Results, May 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

Location	Sample Date	Time	Fluorometer (relative fluorescence units) x100xmin	x100x3.16	x100x10	x100x31.6	Bottle type	Lab Date	Notes
LS	17-May	11:15	0.1	0.25	0.75	2.7	br 100ml	5/30	
LS	17-May	15:15	0.15	0.25	0.8	2.7	br 100ml	5/30	
LS	17-May	19:15	0.1	0.25	0.9	2.7	br 100ml	5/30	
LS	17-May	23:15	0.1	0.25	0.9	2.7	br 100ml	5/30	
LS	18-May	3:15	0.1	0.25	0.8	2.7	br 100ml	5/30	
LS	18-May	7:15	0.1	0.25	0.75	2.6	br 100ml	5/30	fewer flts
LS	18-May	11:15	0.1	0.2	0.8	2.6	br 100ml	5/30	
(data gap)									
LS	18-May	13:15	0.1	0.25	0.75	2.7	cb40ml	lab5/25	**
LS	18-May	19:15	0.15	0.25	0.8	2.6	cb40ml	lab5/25	**
LS	19-May	1:15	0.1	0.25	0.8	2.6	cb40ml	lab5/25	**
LS	19-May	7:15	0.1	0.25	0.8	2.6	cb40ml	lab5/25	**
LS	19-May	13:15	0.1	0.25	0.9	2.9	cb40ml	lab5/25	**
LS	19-May	19:15	0.1	0.25	0.8	2.8	cb40ml	lab5/25	**
LS	20-May	1:15	0.1	0.25	0.75	2.5	cb40ml	lab5/25	**
LS	20-May	7:15	0.1	0.2	0.7	2.5	cb40ml	lab5/25	**
LS	20-May	13:15	0.1	0.2	0.8	2.5	cb40ml	lab5/25	**
LS	20-May	19:15	0.1	0.2	0.75	2.5	cb40ml	lab5/25	**
LS	21-May	1:15	0.1	0.25	0.7	2.4	cb40ml	lab5/25	**
LS	21-May	7:15	0.1	0.2	0.7	2.5	cb40ml	lab5/25	**
LS	21-May	13:15	0.1	0.2	0.8	2.5	cb40ml	lab5/25	**
LS	21-May	19:15	0.1	0.2	0.75	2.5	cb40ml	lab5/25	**
LS	22-May	1:15	0.1	0.2	0.8	2.5	cb40ml	lab5/25	**
LS	22-May	7:15	0.1	0.25	0.7	2.4	cb40ml	lab5/25	**
LS	22-May	13:15					1000ml	lab5/25	Lab opps: dumped.
LS	22-May	19:15	0.1	0.2	0.75	2.5	cb40ml	lab5/25	**
LS	23-May	1:15	0.1	0.2	0.7	2.5	cb40ml	lab5/25	**
LS	23-May	7:15	0.1	0.2	0.7	2.3	cb40ml	lab5/25	**
LS	23-May	13:15	0.1	0.2	0.75	2.5	cb40ml	lab5/25	**
LS	23-May	19:15	0.1	0.2	0.7	2.5	br40ml	lab5/25	**
LS	24-May	1:15	0.1	0.2	0.7	2.3	br40ml	lab5/25	**
LS	24-May	7:15	0.1	0.25	1	2.85	br40ml	lab5/25	**
LS	24-May	13:00	0.1	0.25	0.85	2.6	cb40ml	lab5/25	**

Table 1. Phase I: Seep and Automated Sampler Results, May 2001
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UDEQ/DERR Empire Canyon ESI, Summit County, Utah

Location	Sample Date	Time	Fluorometer (relative fluorescence units) x100xmin	x100x3.16	x100x10	x100x31.6	Bottle type	Lab Date	Notes
Middle Sampler									
MS (grab)	9-May	14:30	0.1	0.2	0.65	2	br 40 ml vial	5/16	
MS (grab)	9-May	15:00	0.1	0.2	0.6	2.1	br 40 ml vial	5/16	
MS (grab)	9-May	15:30	0.1	0.2	0.8	2.7	br 40 ml vial	5/16	
MS (grab)	9-May	16:00	0.15	0.4	1.3	4.3	br 40 ml vial	5/16	
(data gap)									
MS (grab)	9-May	19:35	0.35	0.95	3	9.5	cl 40ml	5/16	v .2
MS (grab)	10-May	0:25	0.2	0.6	2.1	6.4	40ml vial	5/16	v .2
MS (grab)	10-May	2:00	0.25	0.6	2.1	6.6	cl 40ml	5/16	v .2
MS (grab)	10-May	4:45	0.2	0.5	1.7	5.5	40ml vial	5/16	
(data gap)									
MS	10-May	17:50	0.1	0.3	1.1	3.6	cl 40ml	lab 5/17	v .3
MS	10-May	21:50	0.1	0.3	0.9	3.1	cl 40ml	lab 5/17	v .2
MS	11-May	1:50	0.1	0.25	0.9	3	cl 40ml*	lab 5/17	v .2
MS	11-May	5:50	0.1	0.25	0.8	2.7	cl 40ml*	lab 5/17	v .2
MS	11-May	9:50	0.1	0.25	0.8	2.7	cl 40ml*	lab 5/17	
MS	11-May	13:50	0.1	0.25	0.8	2.65	cl 40ml*	lab 5/17	
MS	11-May	17:50	0.15	0.25	0.9	2.8	cl 40ml	lab 5/17	v .2
MS	11-May	21:50	0.1	0.25	0.85	2.7	cl 40ml*	lab 5/17	
MS	12-May	1:50	0.1	0.25	0.9	2.7	cl 40ml**	lab 5/17	
MS	12-May	5:50	0.1	0.25	0.8	2.6	cl 40ml**	lab 5/17	v .2
MS	12-May	9:50	0.1	0.2	0.8	2.6	cl 40ml**	lab 5/17	
MS	12-May	13:50	0.1	0.2	0.8	2.5	cl 40ml**	lab 5/17	v .2
MS	12-May	17:50	0.1	0.25	1	2.9	cl 40ml**	lab 5/17	v .1
MS	12-May	21:50	0.1	0.25	0.9	2.8	cl 40ml**	lab 5/17	
MS	13-May	1:50	0.1	0.25	0.8	2.6	cl 40ml*	lab 5/17	
MS	13-May	5:50	0.1	0.25	0.7	2.5	cl 40ml*	lab 5/17	v .4
MS	13-May	9:50	0.1	0.2	0.7	2.6	cl 40ml*	lab 5/17	
MS	13-May	13:50	0.1	0.25	0.75	2.45	cl 40ml*	lab 5/17	var .4
MS	13-May	17:50	0.1	0.25	0.75	2.6	cl 40ml*	lab 5/17	
MS	13-May	21:50	0.1	0.23	0.8	2.8	cl 40ml*	lab 5/17	
MS	14-May	1:50	0.1	0.25	0.8	2.6	cl 40ml*	lab 5/17	
MS	14-May	5:50	0.1	0.2	0.7	2.5	cl 40ml*	lab 5/17	
MS	14-May	9:50	0.1	0.2	0.7	2.3	cl 40ml*	lab 5/17	
MS	14-May	13:00	0.1	0.25	0.9	2.9	br 100ml	lab 5/30	
MS	14-May	13:50	0.1	0.2	0.65	2.3	cl 40ml*	lab 5/17	v .1
MS (grab)	14-May	16:30	0.1	0.2	0.85	2.7	cl 40ml*	5/17p	
MS	14-May	17:00	0.1	0.3	1.05	3.1	br 100ml	lab 5/30	some flts
MS	14-May	21:00	0.1	0.3	0.9	3	br 100ml	lab 5/30	

Table 1. Phase I: Seep and Automated Sampler Results, May 2001
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UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)						
Location	Sample Date	Time	x100xmin	x100x3.16	x100x10	x100x31.6	Bottle type	Lab Date	Notes
MS	15-May	1:00	0.1	0.25	0.9	2.9	br 100ml	lab5/25	
MS	15-May	5:00	0.1	0.25	0.8	2.7	br 100ml	5/30	
MS	15-May	9:00	0.1	0.25	0.9	2.9	br 100ml	5/30	
MS	15-May	13:00	0.1	0.25	0.8	2.7	br 100ml	5/30	
MS	15-May	17:00	0.15	0.3	1	3.1	br 100ml	5/30	fewer flts
MS	15-May	21:00	0.1	0.3	1.2	3.8	br 100ml	lab5/25	
MS	16-May	1:00	0.1	0.25	0.85	2.8	br 100ml	5/30	fewer flts
MS	16-May	5:00	0.1	0.25	0.9	2.8	br 100ml	5/30	
MS	16-May	9:00	0.1	0.3	0.95	3.4	br 100ml	5/30	some flts
MS	16-May	13:00	0.1	0.25	0.9	3.05	br 100ml	5/30	
MS	16-May	17:00	0.1	0.25	0.9	2.9	br 100ml	5/30	
MS	16-May	21:00	0.15	0.25	0.9	2.7	br 100ml	5/30	
MS	17-May	1:00	0.15	0.25	0.9	2.8	br 100ml	5/30	
MS	17-May	5:00	0.1	0.2	0.9	2.8	br 100ml	5/30	
MS	17-May	9:00	0.1	0.25	0.85	2.8	br 100ml	lab5/25	
MS	17-May	13:00	0.1	0.25	0.9	2.8	br 100ml	lab5/25	
MS	17-May	17:00	0.1	0.25	0.95	2.8	br 100ml	5/30	fewer flts
MS	17-May	21:00	0.1	0.25	0.9	2.7	br 100ml	5/30	fewer flts
MS	18-May	1:00	0.1	0.3	0.8	2.6	br 100ml	lab5/25	
MS	18-May	5:00	0.1	0.2	0.9	2.8	br 100ml	5/30	
MS	18-May	9:00	0.1	0.25	0.8	2.6	br 100ml	lab5/25	
(data gap)									
MS (grab)	24-May	13:00	0.1	0.2	0.8	2.5	br40ml**	5/25	some floats
Upper	9-May	16:45	0.6	1.8	5.9		500ml bottle	5/15	off scale
Sampler	9-May	18:00	0.4	1.2	4.1		500ml bottle	5/15	off scale
US	9-May	19:00	0.4	1	3.3		500ml bottle	5/15	est. 10.4
US	9-May	20:00	0.3	0.85	2.8	9	500ml bottle	5/15	
US	9-May	21:00	0.25	0.65	2.5	8.1	500ml bottle	5/15	
US	9-May	22:00	0.25	0.7	2.3	7.6	500ml bottle	5/15	
US	9-May	23:00	0.25	0.6	2.1	7	500ml bottle	5/15	
US	10-May	0:00:00	0.25	0.6	2	6.4	500ml bottle	5/15	
US	10-May	1:00	0.2	0.6	2	6.5	500ml bottle	5/15	
US	10-May	2:00	0.2	0.55	1.95	6.1	500ml bottle	5/15	
US	10-May	3:00	0.2	0.55	1.85	5.9	500ml bottle	5/15	
US	10-May	4:00	0.2	0.6	1.9	6	500ml bottle	5/15	
US	10-May	5:00	0.2	0.5	1.7	5.8	500ml bottle	5/15	
US	10-May	6:00	0.2	0.5	1.7	5.4	500ml bottle	5/15	
US	10-May	7:00	0.2	0.5	1.6	5.2	500ml bottle	5/15	
US	10-May	8:00	0.2	0.5	1.6	5.1	500ml bottle	5/15	
US	10-May	9:00	0.2	0.5	1.6	5.2	500ml bottle	5/15	
US	10-May	10:00	0.2	0.5	1.6	5.1	500ml bottle	5/15	
US	10-May	11:00	0.15	0.5	1.6	5.2	500ml bottle	5/15	

Table 1. Phase I: Seep and Automated Sampler Results, May 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)						
Location	Sample Date	Time	x100xmin	x100x3.16	x100x10	x100x31.6	Bottle type	Lab Date	Notes
US	10-May	12:00	0.2	0.5	1.6	5.1	500ml bottle	5/15	
US	10-May	13:00	0.2	0.45	1.5	4.8	500ml bottle	5/15	
US	10-May	14:00	0.15	0.4	1.4	4.6	500ml bottle	5/15	
US	10-May	15:00	0.2	0.4	1.4	4.5	500ml bottle	5/15	
US	10-May	16:00	0.15	0.4	1.5	4.8	500ml bottle	5/15	
US	10-May	16:30	0.2	0.45	1.55	4.9	cl 40ml*	lab 5/17	
(data gap)									
US	10-May	20:30	0.2	0.45	1.45	4.4	cl 40ml*	lab 5/17	
US	11-May	0:30	0.15	0.4	1.3	4.3	cl 40ml*	lab 5/17	
US	11-May	4:30	0.15	0.35	1.2	3.8	cl 40ml*	lab 5/17	
US	11-May	8:30	0.15	0.35	1.15	3.8	cl 40ml*	lab 5/17	
US	11-May	12:30	0.15	0.35	1.15	3.8	cl 40ml*	lab 5/17	
US	11-May	16:30	0.15	0.35	1.15	3.7	cl 40ml*	lab 5/17	
US	11-May	20:30	0.1	0.3	1.1	3.55	cl 40ml*	lab 5/17	
US	12-May	0:30	0.1	0.3	1	3.3	cl 40ml*	lab 5/17p	
US	12-May	4:30	0.1	0.3	0.95	3.2	cl 40ml*	lab 5/17p	
US	12-May	8:30	0.1	0.3	1	3	cl 40ml*	lab 5/17p	
US	12-May	12:30	0.1	0.25	0.95	3	cl 40ml*	lab 5/17p	
US	12-May	16:30	0.1	0.3	1.05	3.6	cl 40ml*	lab 5/17p	
US	12-May	20:30	0.15	0.35	1.05	3.4	cl 40ml*	lab 5/17p	
US	13-May	0:30	0.1	0.3	0.9	3	cl 40ml*	lab 5/17p	
(data gap)									
US	14-May	12:00	0.15	0.3	1	3.2	br 100ml	5/30	
US	14-May	16:00	0.15	0.3	1.1	3.4	br 100ml	5/30	fewer flts
US	14-May	20:00	0.15	0.35	1.1	3.6	br 100ml	5/30	
US	15-May	0:00	0.15	0.3	1.05	3.4	br 100ml	5/30	dlb ck 3.1-3.6
US	15-May	4:00	0.15	0.3	1.05	3.2	br 100ml	5/30	
US	15-May	8:00	0.1	0.3	1.05	3.4	br 100ml	5/30	
US	15-May	12:00	0.15	0.3	1	3.1	br 100ml	5/30	
US	15-May	16:00	0.15	0.35	1.1	3.6	br 100ml	5/30	
US	15-May	20:00	0.1	0.3	1	3.3	br 100ml	5/30	
US	16-May	0:00	0.15	0.3	1	3.2	br 100ml	5/30	
US	16-May	4:00	0.15	0.3	1.05	3.4	br 100ml	5/30	
US	16-May	8:00	0.15	0.3	1.05	3.3	br 100ml	5/30	
US	16-May	12:00	0.1	0.3	1	3.4	br 100ml	5/30	
US	16-May	16:00	0.15	0.35	1.3	4.2	br 100ml	5/30	some flts
US	16-May	20:00	0.15	0.3	1	3.2	br 100ml	5/30	
US	17-May	0:00	0.15	0.3	1.05	3.3	br 100ml	5/30	

Table 1. Phase I: Seep and Automated Sampler Results, May 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)						
Location	Sample Date	Time	x100xmin	x100x3.16	x100x10	x100x31.6	Bottle type	Lab Date	Notes
US	5/17/01	4:00	0.15	0.25	0.9	3	br 100ml	lab5/25	
US	5/17/01	8:00	0.15	0.3	0.9	3	br 100ml	lab5/25	
US	5/17/01	12:00	0.15	0.3	1	3.3	br 100ml	lab5/25	
US	5/17/01	16:00	0.15	0.35	1.2	4.2	br 100ml	lab5/25	some flts
US	5/17/01	20:00	0.15	0.3	1	3.1	br 100ml	lab5/25	
US	5/18/01	0:00	0.1	0.3	0.95	3.1	br 100ml	5/30	
US	5/18/01	4:00	0.1	0.25	0.9	2.9	br 100ml	5/30	
US	5/18/01	8:00	0.1	0.3	0.95	3	br 100ml	lab5/25	

NOTES:
Bottle type: br=amber glass, cl=clear glass.
* is 5ml rinse **rinsed with sample. Lab work on 5/16 double analyzed vial samples.

Table 2. Phase I: Grab Sample Results, May 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)										
Location	Sample Date	Time	x1xmin	x1x3.16	x1x10	x1x31.6	x100xmin	x100x3.16	x100x10	x100x31.6	Bottle type*	Notes	Lab Date
salt injection point	7-May		0	0	0	0.1	0.1	0.2	0.8	2.6	100ml bottle		16-May
stream at Seep 4	9-May	23:25			0.05	0.1	0.15	0.5	1.65	5.3	cl 40ml	var .3	16-May
above third culvert	9-May	21:00			0.05	0.1	0.3	0.75	2.5	8.2	cl 40ml	var .4	16-May
in stream at iron gate	9-May	23:00				0.1	0.2	0.55	1.9	5.9	cl 40ml	var .4	16-May
in stream at iron gate	9-May	23:55				0.1	0.15	0.55	1.75	5.8	40ml vial		16-May
in stream at iron gate	10-May	0:25				0.1	0.2	0.5	1.7	5.6	40ml vial		16-May
in stream at iron gate	10-May	2:00			0.05	0.1	0.2	0.5	1.7	5.3	cl 40ml		16-May
in stream at iron gate	10-May	4:45	0	0	0	0	0.15	0.4	1.35	4.4	40ml vial		16-May
Daly Draw	30-Apr		0	0	0	-0.1	0.1	0.2	0.8	2.7	100ml bottle (AVJ)		16-May
below Walker-Webster flume at bend in road	9-May	21:00	0.05	0.1	0.3	1	3.1	9.2 steady	off	off	40ml vial	lots of floates	16-May
below bend in road; above second culvert	9-May	21:00	0.05	0.1	0.3	1.05	3.05	9.2 steady	off	off	40ml vial	lots of floates	16-May

*Bottle type: cl=clear glass.

Table 3 Phase I: Data Summary, May 2001
Tacer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

	[illegible]						
Sample Location	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	5/9, 14:05	(not determined)	(not determined)	(not determined)	20	5/9, 14:05 to 5/24, 13:00	1,750
[illegible]	5/9, 14:07	(not determined)	(not determined)	(not determined)	27	5/9, 14:07 to 5/24, 13:00	1,820
[illegible]	5/9, 14:46	(not determined)	(Not determined. A spike occurred on 5/14 at 20:05.)	(not determined)	26	5/9, 14:46 to 5/24, 13:00	1,870
[illegible]	5/9, 14:15	(not determined)	(not determined)	(not determined)	24	5/9, 14:15 to 5/24, 13:00	1,920
Upper Sampler	(No samples collected prior to dye injection.)	(No data of first arrival. First sample on 5/9 at 16:45.)	0.059 ppbPeak with the first sample at 16:45, 5/9	0.009 ppb; on 5/13, 00:30	63	5/9, 16:45 to 5/18, 8:00	1,030
Middle Sampler	(No samples collected prior to dye injection.)	5/4, 15:30	0.03 ppb; Between 16:00 & 19:35, 5/9	0.0065 ppb; on 5/11, 05:50	47	5/10, 17:50 to 5/18, 9:00	1,750
Lower Sampler [illegible]	0.007ppb; on 5/7, 11:15 to 5/9, 12:00	5/9, between 12:00 and 18:00	0.033 ppb; On 5/9, between 12:00 and 18:00	0.007 ppb; on 5/10, 11:00	104	5/7, 11:15 to 5/24 13:00	1,970

Notes:
Total samples taken: 322 (311 from the above sites and 11 grab samples).
Distance from injection point to lowest sampler is 1,970 feet.
Dye Tracer: 250 ml Rhodamine WT 20% solution injected at 14:05 May 9, 2001.
Samples collected 5/7, 11:15 through 5/24, 13:00 (2 days prior, and 16 days after dye injection). Laboratory analysis dates: May 15, 16, 17, 25, 30.
The study included the use of 3 samplers courtesy of the USGS.
At the time of dye injection no surface water flowed through the Walker-Webster flume.
At 21:00 the stream channel below the Walker-Webster flume,at the bend in the road, was losing surface flow and a trickle (~1gpm) discharged from the second culvert.
Data gaps in sample collection are attributed to weather conditions, equipment operations, and field work schedules.

Table 4a. Phase I: Stream Flow Rates by Date and Time, April-June 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

Date	Time	Flume location	Flume (gage height, feet)	ft^3/sec	GPM	Notes
20-Apr	ND	IG	0.13	ND	ND	Seep at toe, at IG is flowing
23-Apr	ND	IG	0.1	ND	ND	Seep at toe, at IG is dry
23-Apr	ND	DD	dry	ND	ND	dug down through snow, no surface flow observed.
23-Apr	ND	WW	dry	ND	ND	dug down through snow, no surface flow observed.
30-Apr	15:30	DD	dry	ND	ND	
30-Apr	16:50	IG	0.27	0.52	233.38	Judge Tunnel was not turned out.
30-Apr	(later in pm)	DD	0.16	0.11	49.37	(K.Gee) Judge Tunnel was not turned out.
7-May	11:15	IG	0.52	1.43	641.78	tunnel turned out (L.Spangler)
7-May	11:15	IG	0.18	ND	ND	before tunnel turned out (L.Spangler)
7-May	8:00	IG	0.17	ND	ND	Judge Tunnel was not turned out.
7-May	8:00	IG	0.49	1.31	587.93	(K.Gee) Judge Tunnel was turned out.
7-May	16:00	IG	0.19	ND	ND	Judge Tunnel was not turned.
7-May	ND	DD	dry	ND	ND	
7-May	ND	EC	dry	ND	ND	
7-May	ND	WW	dry	ND	ND	
9-May	10:45	DD	0.31	0.32	143.62	3 to 4 feet of snow in canyon.
9-May	10:45	IG	0.31	0.64	287.23	
9-May	ND	EC	dry	ND	ND	Creek flowing ~100 ft upstream of (Empire) culvert (at confluence), ~44 gpm.
9-May	15:30	EC	0.32	0.54	242.35	
9-May	15:30	WW	0.13	0.14	62.83	
9-May	15:30	DD	0.47	0.62	278.26	
9-May	21:15	DD	0.61	0.94	421.87	
9-May	21:15	WW	0.26	0.39	175.03	a trickle (~1 gpm) discharge from second culvert.
9-May	21:15	IG	0.56	1.61	722.57	
9-May	21:15	EC	0.13	0.16	71.81	in stream above confluence, est. 1/2 of WW
10-May	1:05	IG	0.58	1.70	762.96	
10-May	1:20	DD	0.62	0.97	435.34	
10-May	1:25	EC	0.21	0.28	125.66	
10-May	1:35	WW	0.25	0.37	166.06	a trickle (~1 gpm) discharging from second culvert.
10-May	17:30	IG	1.1	4.58	2055.50	seep west of IG is flowing
10-May	17:30	DD	0.71	1.20	538.56	
10-May	17:30	WW	0.4	0.76	341.09	
14-May	11:50	IG	1.15	4.91	2203.61	
14-May	12:20	WW	0.55	1.23	552.02	
14-May	12:50	EC	0.37	0.67	300.70	
14-May	13:00	DD	0.9	1.74	780.91	Stream at salt injection point has moved to opposite side (NE side) of channel.
14-May	15:00	IG	1.26	5.65	2535.72	Judge Tunnel turned out most of the day.
18-May	13:25	IG	1.3	5.93	2661.38	
18-May	17:45	IG	1.35	6.29	2822.95	(L. Spangler)
18-May	ND	WW	0.8	2.18	978.38	
24-May	ND	IG	0.93	3.53	1584.26	
24-May	(am)	DD	0.38	0.45	201.96	
24-May	8:00	WW	0.49	1.03	462.26	
24-May	12:30	WW	0.48	1.00	448.80	
24-May	ND	EC	dry	ND	ND	EC flume is ~400 feet upstream from confluence, observed surface flow ~200 feet upgradient of the confluence and then it disappeared.
4-Jun	ND	WW	0.22	0.19	85.27	
7-Jun	ND	WW	0.1	0.09	40.39	
11-Jun	ND	WW	dry	ND	ND	
11-Jun	ND	DD	dry	ND	ND	
11-Jun	ND	EC	dry	ND	ND	

NOTES:
DD=Daly Draw flume, 6 inches.
EC=Empire Canyon flume, 9 inches
IG=Iron Gate flume, 12 inches.
WW=Walker-Webster flume, 9 inches.
ND=No Data

Table 4b. Phase I: Stream Flow Rates by Location, April-June 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

Flume location	Date	Time	Flume (gage height, feet)	ft^3/sec	GPM	Notes
DD	23-Apr	ND	dry	ND	ND	dug down through snow, no surface flow observed.
DD	30-Apr	15:30	dry	ND	ND	
DD	30-Apr	(later in pm)	0.16	0.11	49.37	(K.Gee) Judge Tunnel was not turned out.
DD	7-May	ND	dry	ND	ND	
DD	9-May	10:45	0.31	0.32	143.62	3 to 4 feet of snow in canyon.
DD	9-May	15:30	0.47	0.62	278.26	
DD	9-May	21:15	0.61	0.94	421.87	
DD	10-May	1:20	0.62	0.97	435.34	
DD	10-May	17:30	0.71	1.20	538.56	
DD	14-May	13:00	0.9	1.74	780.91	Stream at salt injection point has moved to opposite side (NE side) of channel.
DD	24-May	(am)	0.38	0.45	201.96	
DD	11-Jun	ND	dry	ND	ND	
EC	7-May	ND	dry	ND	ND	
EC	9-May	~14:00	dry	ND	ND	Creek flowing ~100 ft upstream of (Empire) culvert (at confluence), ~44 gpm.
EC	9-May	15:30	0.32	0.54	242.35	
EC	9-May	21:15	0.13	0.16	71.81	Estimated stream flow at confluence is half of WW flow rat
EC	10-May	1:25	0.21	0.28	125.66	
EC	14-May	12:50	0.37	0.67	300.70	
EC	24-May	ND	dry	ND	ND	EC flume is ~400 feet upstream from confluence, observed surface flow ~200 feet upgradient of the confluence and then it disappeared.
IG	20-Apr	ND	0.13	ND	ND	seep at toe, at IG is flowing
IG	23-Apr	ND	0.1	ND	ND	seep at toe, at IG is dry
IG	30-Apr	16:50	0.27	0.52	233.38	Judge Tunnel was not turned out.
IG	7-May	8:00	0.49	1.31	587.93	(K.Gee) Judge Tunnel was turned out.
IG	7-May	8:00	0.17	ND	ND	Judge Tunnel was not turned out.
IG	7-May	11:15	0.52	1.43	641.78	tunnel turned out (L.Spangler)
IG	7-May	11:15	0.18	< 0.33	< 148	before tunnel turned out (L.Spangler)
IG	7-May	16:00	0.19	ND	ND	Judge Tunnel was not turned out.
IG	9-May	10:45	0.31	0.64	287.23	
IG	9-May	21:15	0.56	1.61	722.57	tunnel turned out?
IG	10-May	1:05	0.58	1.70	762.96	tunnel truned out?
IG	10-May	17:30	1.1	4.58	2055.50	seep west of IG is flowing
IG	14-May	11:50	1.15	4.91	2203.61	
IG	14-May	15:00	1.26	5.65	2535.72	Judge Tunnel turned out most of the day.
IG	18-May	13:25	1.3	5.93	2661.38	
IG	18-May	17:45	1.35	6.29	2822.95	(L. Spangler)
IG	24-May	ND	0.93	3.53	1584.26	
WW	23-Apr	ND	dry	ND	ND	dug down through snow, no surface flow observed.
WW	7-May	ND	dry	ND	ND	
WW	9-May	15:30	0.13	0.14	62.83	
WW	9-May	21:15	0.26	0.39	175.03	a trickle (~1 gpm) discharging from second culvert.
WW	10-May	1:35	0.25	0.37	166.06	a trickle (~1 gpm) discharging from second culvert.
WW	10-May	17:30	0.4	0.76	341.09	
WW	14-May	12:20	0.55	1.23	552.02	
WW	18-May	ND	0.8	2.18	978.38	
WW	24-May	8:00	0.49	1.03	462.26	
WW	24-May	12:30	0.48	1.00	448.80	
WW	4-Jun	ND	0.22	0.19	85.27	
WW	7-Jun	ND	0.1	0.09	40.39	
WW	11-Jun	ND	dry	ND	ND	

NOTES:
DD = Daly Draw flume, 6 inches.
EC = Empire Canyon flume, 9 inches
IG = Iron Gate flume, 12 inches.
WW = Walker-Webster flume, 9 inches.
ND = No Data

Table 5a. Phase I: Water Data by Date and Time, April-May 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

Date	Time	Location	pH	Conductivity (mS/cm)	Temp (°C)	Dissolved Oxygen (mg/l)
30-Apr	15:05	DD at salt injection point	6.89	0.210	3.1	10.97
30-Apr	15:12	DD at salt injection point	6.80	0.207	2.6	10.94
30-Apr	15:17	DD at salt injection point	6.90	ND	2.5	ND
30-Apr	15:22	DD at salt injection point	7.11	0.218	2.5	10.84
30-Apr	15:27	DD at salt injection point	7.15	0.220	2.4	10.79
30-Apr	16:50	seep at toe of mine waste west of IG	7.33	0.600	5.9	9.85
7-May	10:50	Seep 1	7.27	0.519	5.4	12.13
7-May	10:50	Seep 2	7.27	0.508	5.1	11.80
7-May	10:50	above LS	7.40	0.481	5.2	9.72
7-May	10:50	Seep 3	7.65	0.446	5.3	11.99
7-May	10:50	Seep 4	8.00	0.412	6.3	11.26
7-May	10:50	In stream at seep 1	8.24	0.394	6.6	10.26
9-May	12:45	Seep 4	6.56	0.382	6.1	15.76
9-May	12:45	Seep 2	7.15	0.468	5.5	14.85
9-May	12:45	Seep 1	7.23	0.417	5.7	14.79
9-May	12:45	Seep 3	7.33	0.389	5.7	14.90
9-May	12:45	Seep 4a (between Seeps 3 and 4)	7.34	0.387	7.1	14.17
9-May	12:45	Stream at Seep 1	7.96	0.378	6.7	13.71
9-May	15:50	Empire Canyon flume	7.75	0.346	8.0	ND
14-May	ND	Seep 2	7.49	0.466	5.7	ND
14-May	ND	Seep 3a (between Seeps 2 and 3)	7.53	0.466	5.0	ND
14-May	ND	Seep 4a (between Seeps 3 and 4)	7.53	0.459	4.8	ND
14-May	ND	Seep 3a (between Seeps 2 and 3)	7.58	0.459	5.0	ND
14-May	ND	Seep 4a (between Seeps 3 and 4)	7.58	0.461	5.1	ND
14-May	12:35	WW (sed. Sample location)	8.45	0.407	6.8	ND
14-May	ND	below Seep 4 in stream	8.24	0.367	6.4	ND
14-May	13:00	Salt Injection point (DD)	8.16	0.212	4.9	ND
14-May	14:20	Judge Tunnel turn-out (near storage tank, just below US)	8.02	0.360	5.9	ND
14-May	14:48	below Seep 4 in stream (2)	8.20	0.350	5.9	ND
14-May	15:00	IG	8.22	0.322	6.3	ND
14-May	15:25	upstream from homes in Park City; upstream from last pool.	8.29	0.387	7.6	ND
14-May	14:00	above Judge Tunnel turn-out	8.30	0.282	5.8	ND
24-May	12:30	Seep 2	7.10	0.424	5.8	14.39
24-May	12:30	Seep 4a (between Seeps 3 and 4)	7.60	0.411	6.6	18.51
24-May	12:30	Seep 1	7.70	0.408	5.9	13.70
24-May	12:30	In stream between Seeps 3 and 4	7.80	0.421	7.6	10.50
24-May	12:30	at LS	8.00	0.396	7.7	10.00
24-May	12:30	In stream at Seep 1	8.40	0.362	8.0	10.00
24-May	14:30	Upper Empire Cr. at road crossing.	8.20	0.541	12.1	7.40
24-May	14:30	Upper Empire Creek, 100' below road turn-around	8.27	0.790	16.1	7.50
24-May	12:30	Seep 3	6.20	0.422	7.4	15.88
24-May	ND	Upper DD above culvert	7.80	0.200	8.3	8.89
24-May	ND	Pool at DD flume	8.20	0.235	8.0	10.00
24-May	ND	25 feet above first culvert	8.50	0.368	10.6	9.12

NOTES:
DD = Daly Draw
IG = Iron Gate flume (below LS)
EC = Empire Canyon
LS = Lower Automated Sampler Location
US = Upper Automated Sampler Location
WW = Walker-Webster
ND = No Data

Table 5b. Phase I: Water Data by Location, April-May 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

Location	Date	Time	pH	Conductivity (mS/cm)	Temp (°C)	Dissolved Oxygen (mg/l)
above Judge Tunnel turn-out	14-May	14:00	8.30	0.282	5.8	ND
above LS	7-May	10:50	7.40	0.481	5.2	9.72
at LS	24-May	12:30	8.00	0.396	7.7	10.00
below Seep 4 in stream	14-May	ND	8.24	0.367	6.4	ND
below Seep 4 in stream (2)	14-May	14:48	8.20	0.350	5.9	ND
DD at salt injection point	30-Apr	15:05	6.89	0.210	3.1	10.97
DD at salt injection point	30-Apr	15:12	6.80	0.207	2.6	10.94
DD at salt injection point	30-Apr	15:17	6.90	ND	2.5	ND
DD at salt injection point	30-Apr	15:22	7.11	0.218	2.5	10.84
DD at salt injection point	30-Apr	15:27	7.15	0.220	2.4	10.79
Empire Canyon flume	9-May	15:50	7.75	0.346	8.0	ND
IG	14-May	15:00	8.22	0.322	6.3	ND
In stream at seep 1	7-May	10:50	8.24	0.394	6.6	10.26
In stream at Seep 1	24-May	12:30	8.40	0.362	8.0	10.00
In stream between Seeps 3 and 4	24-May	12:30	7.80	0.421	7.6	10.50
Judge Tunnel turn-out (near storage tank, just below US)	14-May	14:20	8.02	0.360	5.9	ND
WW (sed. Sample location)	14-May	12:35	8.45	0.407	6.8	ND
upstream from homes in Park City; upstream from last pool.	14-May	15:25	8.29	0.387	7.6	ND
Pool at DD flume	24-May	ND	8.20	0.235	8.0	10.00
Salt Injection point (DD)	14-May	13:00	8.16	0.212	4.9	ND
Seep 1	7-May	10:50	7.27	0.519	5.4	12.13
Seep 1	9-May	12:45	7.23	0.417	5.7	14.79
Seep 1	24-May	12:30	7.70	0.408	5.9	13.70
Seep 2	7-May	10:50	7.27	0.508	5.1	11.80
Seep 2	9-May	12:45	7.15	0.468	5.5	14.85
Seep 2	14-May	ND	7.49	0.466	5.7	ND
Seep 2	24-May	12:30	7.10	0.424	5.8	14.39
Seep 3	9-May	12:45	7.33	0.389	5.7	14.90
Seep 3	24-May	12:30	6.20	0.422	7.4	15.88
Seep 3	7-May	10:50	7.65	0.446	5.3	11.99
Seep 3a (between Seeps 2 and 3)	14-May	ND	7.53	0.466	5.0	ND
Seep 3a (between Seeps 2 and 3)	14-May	ND	7.58	0.459	5.0	ND
Seep 4	9-May	12:45	6.56	0.382	6.1	15.76
Seep 4	7-May	10:50	8.00	0.412	6.3	11.26
Seep 4a (between Seeps 3 and 4)	9-May	12:45	7.34	0.387	7.1	14.17
Seep 4a (between Seeps 3 and 4)	14-May	ND	7.58	0.461	5.1	ND
Seep 4a (between Seeps 3 and 4)	14-May	ND	7.53	0.459	4.8	ND
Seep 4a (between Seeps 3 and 4)	24-May	12:30	7.60	0.411	6.6	18.51
seep at toe of mine waste west of IG	30-Apr	16:50	7.33	0.600	5.9	9.85
Stream at Seep 1	9-May	12:45	7.96	0.378	6.7	13.71
25 feet above first culvert	24-May	ND	8.50	0.368	10.6	9.12
Upper DD above culvert	24-May	ND	7.80	0.200	8.3	8.89
Upper Empire Cr. at road crossing.	24-May	14:30	8.20	0.541	12.1	7.40
Upper Empire Creek, 100' below road turn-around	24-May	14:30	8.27	0.790	16.1	7.50

NOTES:
DD = Daly Draw
IG = Iron Gate flume (below LS)
EC = Empire Canyon
LS = Lower Automated Sampler Location
US = Upper Automated Sampler Location
WW = Walker-Webster
ND = No Data

Table 6. Phase II: Sample Results, June 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)									
			Fluorometer x1				Fluorometer x100					
Sample Location	Date	Time	xmin.	x3.16	x10	x31.6	xmin.	x3.16	x10	x31.6	Lab Date*	Notes
Pool below ore bin												
op1	7-Jun	14:30					0.1	0.1	0.45	1.3	lab 6/12, 14:46	
op	7-Jun	17:25					0.1	0.15	0.4	1.2	lab 6/12, 14:46	
op	7-Jun	18:25					0.1	0.15	0.4	1.35	lab 6/13, pm	
op	7-Jun	19:25					0.1	0.15	0.45	1.3	lab 6/13, pm	
op	7-Jun	21:25					0.1	0.15	0.5	1.3	lab 6/13,pm	
op	7-Jun	20:25					0.1	0.1	0.4	1.3	lab 6/13, pm	
op	7-Jun	22:25					0.1	0.1	0.45	1.2	lab 6/13--11:54	
op	7-Jun	23:25					0.1	0.15	0.4	1.2	lab 6/13--11:54	
op	8-Jun	0:25					0.1	0.15	0.4	1.2	lab 6/13--11:54	
op	8-Jun	1:25				0.05	0.1	0.2	0.7	2.3	lab 6/13--11:54	
op	8-Jun	2:25		0.05	0.05	0.15	0.4	1.1	3.7		lab 6/13--11:54	
op	8-Jun	3:25	0.05	0.05	0.15	0.45	1.35	3.95			lab 6/12, 14:46	
op	8-Jun	4:25	0.1	0.15	0.35	1.1	3.5				lab 6/13, pm	
op	8-Jun	5:25	0.1	0.25	0.75	2.5	7.3				lab 6/13--11:54	
op	8-Jun	6:25	0.2	0.35	1.1	3.5					miss marked?	
op	8-Jun	7:25	0.2	0.45	1.4	4.6					lab 6/12, 14:46	
op	8-Jun	8:25	0.3	0.5	1.65	5.2					lab 6/13, pm	
op17	8-Jun	9:25	0.25	0.55	1.8	5.7					lab 6/13, pm	
op18	8-Jun	10:25	0.3	0.65	2.1	6.5					lab 6/13--11:54	
op19	8-Jun	11:25	0.25	0.7	2.1	6.6					lab 6/13--11:54	
op20	8-Jun	12:25	0.25	0.65	2.1	6.55					lab 6/12, 14:46	
op	8-Jun	13:25	0.25	0.6	2	6.3					lab 6/12, 14:46	
op22	8-Jun	14:25	0.25	0.7	2	6.2					lab 6/13, pm	
op	8-Jun	14:50	0.25	0.55	1.75	5.55					lab 6/13--11:54	
op1	8-Jun	15:40	0.25	0.55	1.8	5.6					lab 6/12, 14:46	
op2	8-Jun	19:40	0.2	0.45	1.45	4.65					lab 6/13, pm	
op3	8-Jun	23:40	0.1	0.35	1.1	3.35	10				lab 6/15, pm	
op4	9-Jun	3:40	0.2	0.3	0.9	2.95	8.9				lab 6/15, pm	
op5	9-Jun	7:40	0.15	0.3	0.8	2.55	7.9				lab 6/15, pm	
op6	9-Jun	11:40	0.15	0.25	0.65	2.1	6.3				lab 6/13, pm	
op7	9-Jun	15:40	0.1	0.25	0.7	2.15	6.65				lab 6/15, pm	
op8	9-Jun	19:40	0.1	0.2	0.5	1.6	5				lab end 6/13, 17:44	
op9	9-Jun	23:40	0.1	0.15	0.45	1.5	4.6				lab 6/15, pm	
op10	10-Jun	3:40	0.1	0.2	0.45	1.45	4.45				lab 6/15, pm	
op11	10-Jun	7:40	0.1	0.15	0.4	1.2	3.65				lab 6/15, pm	
op10	10-Jun	11:40	0.1	0.15	0.4	1.25	3.8				lab 6/15, pm	
op13	10-Jun	15:40	0.1	0.15	0.35	1.1	3.3				lab 6/15, pm	
op14	10-Jun	19:40	0.1	0.15	0.35	1.1	3.35	9.85			lab 6/18, 10:00	
(data gap)												
op	11-Jun	12:47	0.05	0.05	0.2	0.65	1.9	5.6			lab 6/18, 10:00	
op	11-Jun	15:35	0.05	0.1	0.2	0.7	2	6.1			lab 6/13, pm	
(data gap)												
op	25-Jun	12:00				0.1	0.3	0.75	2.6	8.3	lab6/26	Alan, sampled
(data gap)												
op	28-Jun	11:47					0.3	0.8	2.8	8.7	lab7/5	Alan, sampled
(data gap)												
op	2-Jul	12:40					0.3	0.75	2.5	8.1	lab7/5	Alan, sampled

Table 6. Phase II: Sample Results, June 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)									
			Fluorometer x1				Fluorometer x100					
Sample Location	Date	Time	xmin.	x3.16	x10	x31.6	xmin.	x3.16	x10	x31.6	Lab Date*	Notes
Toe of mine waste	1-Jun	12:00					0.1	0.15	0.4	1.3	lab 6/13--11:54	
toe	1-Jun	16:00					0.1	0.15	0.45	1.4	lab 6/12, 14:46	
toe	1-Jun	20:00					0.05	0.1	0.45	1.45	lab 6/18, 10:00	
toe	1-Jun	24:00:00					0.05	0.1	0.4	1.35	lab 6/12, 14:46	
toe	2-Jun	4:00					0.1	0.2	0.4	1.3	lab 6/12, 14:46	
toe	2-Jun	8:00					0.1	0.15	0.4	1.25	lab 6/12, 14:46	
toe	2-Jun	12:00				0.05	0.1	0.2	0.5	1.5	lab 6/12, 14:46--17:15	
toe	2-Jun	15:30				0.05	0.1	0.15	0.4	1.3	lab 6/12, 14:46	
toe	2-Jun	16:00					0.1	0.2	0.4	1.25	lab 6/12, 14:46	
toe	2-Jun	20:00					0.1	0.15	0.5	1.3	lab 6/18, 10:00	
(data gap)												
toe	4-Jun	10:00					0.1	0.15	0.4	1.3	lab 6/12, 14:46	
toe	4-Jun	13:32					0.1	0.1	0.45	1.2	lab 6/13--11:54	
(data gap)												
toe	7-Jun	14:50					0.05	0.1	0.35	1.3	lab 6/12, 14:46	
toe	7-Jun	16:35					0.1	0.15	0.45	1.25	lab 6/13--11:54	
toe	7-Jun	17:35					0.1	0.15	0.4	1.35	lab 6/13, pm	
toe	7-Jun	18:35					0.1	0.15	0.35	1.35	lab 6/13--11:54	
toe	7-Jun	19:35					0.1	0.15	0.35	1.3	lab 6/13--11:54	
toe	7-Jun	20:35					0.1	0.15	0.45	1.3	lab 6/13--11:54	
toe	7-Jun	21:35					0.05	0.1	0.5	1.3	lab 6/18, 10:00	
toe	7-Jun	22:35					0.1	0.15	0.45	1.45	lab 6/18, 10:00	
toe	7-Jun	23:35					0.1	0.15	0.45	1.2	lab 6/13--11:54	
toe	8-Jun	0:35					0.1	0.2	0.45	1.3	lab 6/18, 10:00	
toe	8-Jun	1:35					0.1	0.15	0.45	1.3	lab 6/13, pm	
toe	8-Jun	2:35					0.1	0.15	0.35	1.3	lab 6/13, pm	
toe	8-Jun	3:35					0.1	0.15	0.4	1.25	lab 6/13--11:54	
toe	8-Jun	4:35					0.1	0.15	0.4	1.35	lab 6/18, 10:00	
toe	8-Jun	5:35					0.1	0.15	0.4	1.2	lab 6/13--11:54	
toe	8-Jun	6:35					0.1	0.1	0.35	1.3	lab 6/13--11:54	
toe	8-Jun	7:35					0.1	0.1	0.4	1.3	lab 6/13--11:54	
toe	8-Jun	8:35					0.1	0.15	0.35	1.3	lab 6/13, pm	
toe	8-Jun	9:35					0.1	0.1	0.4	1.3	lab 6/13, pm	
toe	8-Jun	10:35					0.1	0.15	0.4	1.3	lab 6/15, pm	
toe	8-Jun	11:35					0.1	0.1	0.35	1.3	lab 6/13, pm	
toe	8-Jun	12:35					0.05	0.15	0.4	1.3	lab 6/13--11:54	
toe	8-Jun	13:35					0	0.1	0.4	1.4	lab 6/12, 14:46	
toe1	8-Jun	14:20					0.1	0.15	0.45	1.4	lab 6/13, pm	
toe2	8-Jun	18:20					0.15	0.25	0.9	2.7	lab 6/15, pm	
toe3	8-Jun	22:20				0.1	0.25	0.6	2	6.4	lab 6/15, pm	
toe4	9-Jun	2:20	0	0	0.05	0.2	0.45	1.3	4.3		lab 6/15, pm	
toe5	9-Jun	6:20	0	0.05	0.1	0.2	0.7	1.95	6.5		lab 6/15, pm	
toe6	9-Jun	10:20	0.05	0.05	0.1	0.35	0.1	2.8	8.95		lab 6/15, pm	
toe7	9-Jun	14:20	0	0.05	0.2	0.4	1.3	3.8			lab 6/15, pm	
toe8	9-Jun	18:20	0	0.05	0.15	0.5	1.5	4.3			lab 6/15, pm	
toe9	9-Jun	22:20	0.05	0.1	0.2	0.6	1.85	5.5			lab 6/18, 10:00	
toe10	10-Jun	2:20	0.05	0.1	0.2	0.6	1.8	5.2			lab 6/15, pm	
toe11	10-Jun	6:20	0.1	0.1	0.2	0.7	2.1	6.25			lab 6/15, pm	
toe12	10-Jun	10:20	0.05	0.1	0.2	0.7	2.15	6.5			lab 6/18, 10:00	
toe13	10-Jun	14:20	0.05	0.1	0.2	0.7	2.2	6.7			lab 6/18, 10:00	
toe14	10-Jun	18:20		0.15	0.2	0.65	2.1	6.35			lab 6/18, 10:00	
toe 15	10-Jun	22:20	0.05	0.1	0.3	0.65	2.1	6.3			lab 6/13, pm	
toe16	11-Jun	2:20	0.1	0.1	0.2	0.7	2.2	6.6			lab 6/13, pm	
toe 17	11-Jun	6:20	0.05	0.1	0.2	0.75	2.2	6.5			lab 6/13, pm	
toe18	11-Jun	10:20	0.05	0.1	0.2	0.75	2.2	6.6			lab 6/18, 10:00	

Table 6. Phase II: Sample Results, June 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)									
			Fluorometer x1				Fluorometer x100					
Sample Location	Date	Time	xmin.	x3.16	x10	x31.6	xmin.	x3.16	x10	x31.6	Lab Date*	Notes
toe1	11-Jun	14:10	0.05	0.05	0.2	0.7	2.1	6.3			lab 6/15, 9:45:00 AM	
toe2	11-Jun	18:10	0.05	0.05	0.2	0.6	1.95	5.9			lab 6/15, 9:50:00 AM	
toe3	11-Jun	22:10	0.05	0.1	0.2	0.6	1.8	5.5			lab 6/15, am	
toe4	12-Jun	2:10	0.05	0.1	0.2	0.6	1.9	5.55			lab 6/15, am	
toe5	12-Jun	6:10	0.05	0.1	0.2	0.6	1.8	5.5			lab 6/15, am	
toe6	12-Jun	10:10	0.06	0.1	0.2	0.6	1.8	5.5			lab 6/15, am	
toe7	12-Jun	14:10	0.05	0.05	0.2	0.6	1.8	5.35			lab 6/15, am	
toe8	12-Jun	18:10	0.05	0.1	0.2	0.55	1.7	5.3			lab 6/15, am	
toe13	13-Jun	2:10		0.1	0.2	0.5	1.55	4.55			lab 6/15, am	
(data gap)												
toe14	13-Jun	18:10	0.05	0.1	0.15	0.45	1.5	4.4			lab 6/15, am	
toe15	13-Jun	22:10	0.05	0.05	0.2	0.45	1.55	4.55			lab 6/15, am	
toe16	14-Jun	2:10	0.05	0.05	0.2	0.45	1.4	4.2			lab 6/15, am	
(data gap)												
toe	14-Jun	14:40	0.05	0.05	0.2	0.4	1.3	3.9			lab 6/20, am	
toe	14-Jun	20:40		0.05	0.15	0.45	1.2	3.3			lab 6/20, am	
toe	15-Jun	2:40		0.05	0.15	0.35	1.2	3.5			lab 6/20, am	
toe	15-Jun	8:40		0.1	0.15	0.4	1.2	3.5			lab 6/20, am	
toe	15-Jun	14:40	0.05	0.05	0.2	0.4	1.2	3.5			lab 6/20, am	
toe	15-Jun	20:40		0.05	0.15	0.35	1.1	3.35			lab 6/20, am	
toe	16-Jun	2:40	0.05	0.05	0.15	0.35	1.1	3.1			lab 6/20, am	
toe	16-Jun	8:40			0.15	0.35	1.1	3	9.7		lab 6/20, am	
toe	16-Jun	14:40		0.05	0.1	0.45	1.2	3.6			lab 6/20, am	floats
Seep at power pole												
PP	7-Jun	15:45					0.1	0.15	0.55	1.9	lab 6/18, am	
PP	7-Jun	16:30					0.1	0.3	0.7	2.4	lab 6/13--11:54	floats
PP	7-Jun	17:15					0.1	0.15	0.5	1.3	lab 6/13--11:54	
PP	7-Jun	18:00					0.1	0.15	0.45	1.5	lab 6/12, 14:46	
(data gap)												
PP	8-Jun	14:00					0.1	0.15	0.45	1.25	lab 6/15, pm	
PP	8-Jun	18:00					0.05	0.15	0.35	1.3	lab 6/15, pm	
PP	8-Jun	22:00					0.1	0.15	0.35	1.2	lab 6/13, pm	
PP	9-Jun	2:00					0.1	0.15	0.4	1.4	lab 6/15, pm	
PP	9-Jun	6:00					0.05	0.15	0.4	1.2	lab 6/15, pm	
PP	9-Jun	10:00					0.1	0.15	0.35	1.3	lab 6/13, pm	
PP	9-Jun	14:00					0.1	0.15	0.4	1.25	lab 6/13, pm	
PP	9-Jun	18:00					0.1	0.1	0.4	1.2	lab 6/15, pm	
PP	9-Jun	22:00					0.05	0.1	0.4	1.2	lab 6/15, pm	
PP	10-Jun	2:00					0.1	0.2	0.35	1.2	lab 6/13, pm	
PP	10-Jun	6:00					0.05	0.15	0.4	1.1	lab 6/15, pm	
PP	10-Jun	10:00					0.1	0.15	0.4	1.2	lab 6/15, pm	
PP 1	10-Jun	14:00					0.1	0.15	0.4	1.3	lab 6/15, pm	
PP 2	10-Jun	18:00					0.05	0.15	0.2	1.3	lab 6/15, pm	
PP	10-Jun	22:00					0.1	0.15	0.4	1.2	lab 6/15, pm	
PP 3	11-Jun	2:00					0.1	0.15	0.45	1.4	lab 6/13, pm	
PP	11-Jun	6:00					0.1	0.1	0.4	1.3	lab 6/15, pm	
PP	11-Jun	10:00					0.2	0.45	1.5	4.7	lab16:14	contaminated?
PP	11-Jun	13:10					0.1	0.15	0.4	1.4	lab 6/15, am	
PP	11-Jun	17:10					0.05	0.15	0.4	1.2	lab 6/15, am	
PP	11-Jun	21:10					0.1	0.15	0.4	1.3	lab 6/15, am	
PP	12-Jun	1:10					0.1	0.15	0.4	1.3	lab 6/15, am	
PP	12-Jun	5:10					0.1	0.15	0.5	1.4	lab 6/15, am	
PP	12-Jun	9:10					0.1	0.15	0.4	1.3	lab 6/15, am	
PP	12-Jun	13:10					0.1	0.15	0.5	1.5	lab 6/15, am	

Table 6. Phase II: Sample Results, June 2001
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)									
			Fluorometer x1				Fluorometer x100					
Sample Location	Date	Time	xmin.	x3.16	x10	x31.6	xmin.	x3.16	x10	x31.6	Lab Date*	Notes
PP	12-Jun	17:10					0.1	0.15	0.5	1.55	lab 6/15, am	
PP	12-Jun	21:10					0.1	0.2	0.65	1.9	lab 6/15, am	
PP	13-Jun	1:10					0.1	0.15	0.5	1.55	lab 6/15, am	
PP	13-Jun	9:10					0.1	0.2	0.6	1.7	lab 6/15, am	
(data gap)												
PP	14-Jun	1:10					0.1	0.15	0.55	1.9	lab 6/15, am	
PP	14-Jun	5:10				0.05	0.1	0.15	0.55	1.9	lab 6/15, am	
(data gap)												
PP	14-Jun	13:30				0.1	0.2	0.65	2.2	6.9	lab 6/15, am	grab,nearest seep, Ann
PP	14-Jun	13:45					0.1	0.2	0.7	2.3	lab 6/20, am	2 collected at once, read same.
PP	14-Jun	14:30					0.1	0.2	0.75	2.35	lab 6/20, am	
PP	14-Jun	20:30					0.1	0.2	0.7	2.5	lab 6/20, am	
PP	15-Jun	2:30					0.1	0.2	0.75	2.5	lab 6/20, am	
PP	15-Jun	8:30					0.1	0.25	0.8	2.6	lab 6/20, am	
PP	15-Jun	14:30					0.1	0.3	0.85	2.8	lab 6/20, am	
PP	15-Jun	20:30					0.1	0.3	0.9	2.8	lab 6/20, am	
PP	16-Jun	2:30					0.15	0.3	0.9	2.95	lab 6/20, am	
PP	16-Jun	8:30					0.1	0.3	1	3.3	lab 6/20, am	
PP	16-Jun	14:30				0.1	0.1	0.3	1.1	3.35	lab 6/20, am	
PP	16-Jun	20:30					0.1	0.3	1.1	3.3	lab 6/20, am	
PP	17-Jun	2:30					0.15	0.4	1.15	3.6	lab 6/20, am	
PP	17-Jun	8:30					0.15	0.4	1.3	4	lab 6/20, am	
PP	17-Jun	14:30				0.05	0.2	0.4	1.25	3.9	lab 6/20, am	
PP	17-Jun	20:30				0.1	0.1	0.35	1.2	4	lab 6/20, am	
PP	18-Jun	2:30					0.15	0.4	1.35	4.3	lab 6/20, am	
PP	18-Jun	8:30					0.15	0.4	1.35	4.2	lab 6/22	
PP	18-Jun	14:30					0.15	0.4	1.4	4	lab 6/22	
PP	18-Jun	20:30					0.15	0.45	1.5	4.2	lab 6/22	
PP	19-Jun	2:30					0.15	0.45	1.4	4.6	lab 6/22	
PP	19-Jun	8:30					0.2	0.45	1.5	4.9	lab 6/22	
PP	19-Jun	14:30					0.2	0.5	1.55	4.9	lab 6/22	
PP	19-Jun	16:30					0.2	0.45	1.5	4.9	lab 6/22	
PP	19-Jun	22:30					0.2	0.5	1.55	4.9	lab 6/22	
PP	20-Jun	4:30					0.2	0.55	1.6	5	lab 6/22	
PP	20-Jun	10:30					0.2	0.5	1.7	5.4	lab 6/22	
PP	20-Jun	16:30					0.2	0.45	1.7	5	lab 6/22	
PP	20-Jun	22:30					0.2	0.5	1.65	5.7	lab 6/22	5.4-6
PP	21-Jun	4:30					0.2	0.5	1.6	5.5	lab 6/22	
PP	21-Jun	10:30					0.25	0.5	1.7	5.5	lab 6/22	
PP	21-Jun	16:30					0.2	0.5	1.6	5.3	lab 6/22	
PP	21-Jun	22:30					0.2	0.55	1.75	5.7	lab 6/22	
PP	22-Jun	4:30					0.2	0.5	1.7	5.7	lab 6/22	
PP	22-Jun	10:30					0.2	0.5	1.8	6	lab 6/22	5.7-6.2
PP	22-Jun	11:30					0.2	0.5	1.8	5.7	lab 6/22	nearest to seep
(data gap)												
PP	25-Jun	11:45					0.25	0.6	1.9	6	lab6/25	Alan, sample
(data gap)												
PP	28-Jun	11:40					0.25	0.6	1.9	6.1	lab7/5	Alan, sample
(data gap)												
PP	2-Jul	13:05					0.25	0.6	2.1	6.6	lab7/5	Alan, sample

Table 6. Phase II: Sample Results, June 2001
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			Fluorometer (relative fluorescence units)									
			Fluorometer x1				Fluorometer x100					
Sample Location	Date	Time	xmin.	x3.16	x10	x31.6	xmin.	x3.16	x10	x31.6	Lab Date*	Notes
In pool in stream at power pole	1-Jun	11:30					0.05	0.15	0.4	1.4	lab 6/12, 14:46	
P-str	1-Jun	15:30					0.1	0.15	0.4	1.3	lab 6/12, 14:46	
P-str	1-Jun	19:30					0.05	0.1	0.45	1.3	lab 6/13--11:54	
P-str	1-Jun	23:30					0.1	0.15	0.4	1.35	lab 6/13, pm	
P-str	2-Jun	3:30					0.1	0.1	0.5	1.3	lab 6/12, 14:46	
P-str	2-Jun	7:30					0.1	0.15	0.4	1.4	lab 6/13, pm	
P-str	2-Jun	11:30					0.1	0.15	0.4	1.4	lab 6/18, am	
P-str	2-Jun	19:30					0.05	0.15	0.4	1.3	lab 6/12, 14:46	
P-str	2-Jun	23:30					0.1	0.15	0.45	1.3	lab 6/12, 14:46	
P-str	3-Jun	3:30					0.1	0.1	0.4	1.3	lab 6/12, 14:46	
P-str	3-Jun	7:30					0.05	0.1	0.4	1.4	lab 6/12, 14:46	
P-str	3-Jun	11:30					0.05	0.1	0.5	1.3	lab 6/12, 14:46	
P-str	3-Jun	15:30					0.1	0.2	0.45	1.3	lab 6/13, pm	
P-str	3-Jun	19:30					0.1	0.1	0.4	1.5	lab 6/12, 14:46	
P-str	3-Jun	23:30					0.1	0.2	0.4	1.3	lab 6/12, 14:46	
P-str	4-Jun	3:30					0.1	0.15	0.4	1.4	lab 6/18, am	
P-str	4-Jun	7:30					0.1	0.15	0.35	1.25	lab 6/12, 14:46	
P-str	4-Jun	14:00					0.1	0.15	0.4	1.3	lab 6/12, 14:46	
P-str	4-Jun	20:00					0.1	0.15	0.4	1.3	lab 6/12, 14:46	
(data gap)												
P-str	5-Jun	8:00					0.1	0.15	0.4	1.4	lab 6/12, 14:46	
P-str	5-Jun	14:00					0.1	0.15	0.4	1.25	lab 6/12, 14:46	
P-str	5-Jun	20:00					0.1	0.15	0.45	1.3	lab 6/13--11:54	
P-str	6-Jun	2:00					0.1	0.2	0.45	1.4	lab 6/18, am	
(data gap)												
P-str	7-Jun	2:00					0.1	0.15	0.45	1.3	lab 6/13--11:54	
P-str	7-Jun	15:00					0.1	0.15	0.45	1.4	lab 6/12, 14:46	
P-str	7-Jun	19:25					0.1	0.1	0.35	1.35	lab 6/13, pm	contaminated ?
White Pipe	7-Jun	20:05					0.1	0.15	0.4	1.3	lab 6/18, am	
wp	7-Jun	21:05					0.1	0.1	0.25	1.2	lab 6/12, 14:46	
wp	7-Jun	22:05					0.05	0.15	0.35	1.15	lab 6/13, pm	
wp	7-Jun	23:05					0.1	0.15	0.25	1.2	lab 6/12, 14:46	
wp	8-Jun	0:05					0.1	0.1	0.25	1.2	lab 6/12, 14:46	
wp	8-Jun	1:05					0.1	0.15	0.45	1.25	lab 6/12, 14:46	
wp	8-Jun	2:05					0.1	0.15	0.35	1.2	lab 6/18, am	
wp	8-Jun	3:05					0.05	0.15	0.35	1.2	lab 6/13--11:54	
wp	8-Jun	4:35					0.1	0.15	0.45	1.3	lab 6/18, am	
wp	8-Jun	5:05					0.1	0.1	0.35	1.2	lab 6/13, pm	
wp	8-Jun	6:05				0.05	0.05	0.15	0.35	1.2	lab 6/13--11:54	
wp	8-Jun	7:05					0.05	0.1	0.35	1.1	lab 6/12, 14:46	
wp	8-Jun	8:05					0.1	0.15	0.35	1.3	lab 6/13,pm	
wp	8-Jun	9:05					0.1	0.15	0.45	1.3	lab6/18,11:54	
wp	8-Jun	10:05					0.1	0.15	0.35	1.25	lab 6/13, pm	
wp	8-Jun	11:05					0.1	0.1	0.35	1.1	lab 6/13--11:54	
wp	8-Jun	12:05					0.1	0.15	0.4	1.2	lab 6/15, pm	
wp	8-Jun	13:05					0.1	0.1	0.35	1.2	lab 6/13, pm	
wp	8-Jun	14:05					0.1	0.15	0.45	1.4	lab 6/13, pm	
wp1	8-Jun	14:40					0.1	0.15	0.4	1.3	lab 6/18, am	
wp2	8-Jun	18:40					0.1	0.15	0.4	1.3	lab 6/18, am	
wp3	8-Jun	22:40					0.1	0.15	0.4	1.3	lab 6/18, am	
wp4	9-Jun	2:40					0.05	0.15	0.4	1.3	lab 6/18, am	
wp5	9-Jun	6:40					0.1	0.15	0.4	1.3	lab 6/18, am	
wp6	9-Jun	10:40					0.1	0.2	0.45	1.4	lab 6/18, am	
wp7	9-Jun	14:40					0.1	0.2	0.55	1.8	lab 6/18, am	
wp8	9-Jun	18:40					0.1	0.2	0.7	2.2	lab 6/18, am	
wp9	9-Jun	22:40					0.1	0.2	0.8	2.6	lab 6/18, am	

Table 6. Phase II: Sample Results, June 2001
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			Fluorometer (relative fluorescence units)									
			Fluorometer x1				Fluorometer x100					
Sample Location	Date	Time	xmin.	x3.16	x10	x31.6	xmin.	x3.16	x10	x31.6	Lab Date*	Notes
wp10	10-Jun	2:40					0.15	0.3	0.9	3.1	lab 6/18, am	
wp11	10-Jun	6:40					0.15	0.35	1.1	3.7	lab 6/18, am	
wp12	10-Jun	10:40					0.15	0.4	1.25	3.9	lab 6/13, pm	
wp13	10-Jun	14:40					0.2	0.4	1.35	4.5	lab 6/18, am	
wp14	10-Jun	18:40					0.2	0.45	1.5	4.7	lab 6/18, am	
wp16	11-Jun	2:40					0.2	0.55	1.7	5.5	lab 6/18, am	
wp17	11-Jun	6:40					0.2	0.5	1.7	5.4	lab 6/13, pm	
wp18	11-Jun	10:40				0.05	0.2	0.6	1.7	5.4	lab 6/15, pm	
wp1	11-Jun	13:30					0.2	0.5	1.6	5.2	lab 6/15, am	
wp2	11-Jun	17:30					0.2	0.6	1.7	5.5	lab 6/15, am	
wp3	11-Jun	21:30					0.2	0.45	1.55	5	lab 6/15, am	
wp4	12-Jun	1:30				0.05	0.25	0.5	1.6	5.25	lab 6/15, am	no sample at Power Pole, 17:10, 6/13
wp5	12-Jun	5:30					0.2	0.5	1.6	5	lab 6/15, am	
wp6	12-Jun	9:10				0.1	0.2	0.5	1.6	4.9	lab 6/15, am	
wp8	12-Jun	17:30				0.1	0.2	0.45	1.45	4.4	lab 6/15, pm	
wp9	12-Jun	21:30					0.15	0.4	1.4	4.6	lab 6/15, pm	
wp10	13-Jun	1:30					0.2	0.4	1.4	4.5	lab 6/15, pm	
wp11	13-Jun	5:30					0.2	0.4	1.3	4.3	lab 6/15, am	couple floats
wp12	13-Jun	9:30				0.1	0.15	0.35	1.25	4	lab 6/15, am	
wp13	13-Jun	13:30					0.2	0.35	1.1	3.6	lab 6/15, am	couple floats
wp14	13-Jun	17:30					0.15	0.4	1.1	3.6	lab 6/15, pm	
wp15	13-Jun	21:30					0.15	0.3	1.1	3.5	lab 6.15, am	couple floats
wp14	14-Jun	1:30					0.2	0.35	1.1	3.5	lab 6/15, pm	couple floats
wp17	14-Jun	5:30					0.15	0.35	1	3.2	lab 6/15,am	
wp18	14-Jun	9:30					0.15	0.3	0.1	3.2	lab 6/15,12:12	
wp	14-Jun	13:45					0.15	0.25	0.9	3	lab 6/15, pm	
wp	14-Jun	20:45					0.1	0.25	0.9	2.9	lab 6/20,am	
wp	15-Jun	2:45					0.1	0.15	0.8	2.7	lab 6/20,am	
wp	15-Jun	8:45					0.1	0.25	0.9	2.6	lab 6/20,am	
wp	15-Jun	14:45					0.1	0.2	0.8	2.5	lab 6/20,am	interruption?no decon?
wp	15-Jun	20:45					0.1	0.25	0.75	2.5	lab 6/20,am	
wp	16-Jun	2:45					0.1	0.2	0.7	2.3	lab 6/20,am	
wp	16-Jun	8:45					0.1	0.25	0.7	2.2	lab 6/20,am	
wp	16-Jun	14:45					0.1	0.2	0.6	1.9	lab 6/20,am	
wp	16-Jun	20:45					0.1	0.2	0.6	2.1	lab 6/20,am	
wp	17-Jun	2:45					0.1	0.2	0.7	2	lab 6/20,am	
wp	17-Jun	8:45					0.1	0.15	0.65	2	lab 6/20,am	
wp	17-Jun	14:45					0.1	0.2	0.6	1.9	lab 6/20,am	
wp	17-Jun	20:45					0.1	0.2	0.6	1.9	lab 6/20,am	
wp	18-Jun	2:45					0.1	0.15	0.6	1.9	lab 6/20,am	loose cap??
wp	18-Jun	8:45					0.1	0.2	0.55	1.75	lab 6/20,am	
wp	18-Jun	14:45					0.1	0.15	0.55	1.8	lab 6/20,am	
wp	18-Jun	20:45					0.1	0.15	0.5	1.8	lab 6/20,am	one float
wp	19-Jun	2:45					0.1	0.2	0.5	1.7	lab 6/20,am	
wp	19-Jun	8:45					0.1	0.15	0.55	1.7	lab 6/20,am	
wp	25-Jun	11:55				0.05	0.05	0.1	0.4	1.3	lab6/26	Alan, grab sample
(data gap)												
wp	28-Jun	11:35					0.05	0.1	0.35	1.25	lab7/5	Alan, grab sample
(data gap)												
wp	2-Jul	12:50					0.05	0.15	0.35	1.25	lab7/5	Alan, grab sample
(data gap)												

Table 6. Phase II: Sample Results, June 2001
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Sample Location	Date	Time	Fluorometer (relative fluorescence units)								Lab Date*	Notes
			Fluorometer x1				Fluorometer x100					
			xmin.	x3.16	x10	x31.6	xmin.	x3.16	x10	x31.6		
1/2 Pool	16-Jun	16:15					0.5	1.4	4.7		lab 6/18, am	
1.5pool	16-Jun	22:15			0.05	0.15	0.45	1.35	4.5		lab 6/18, am	
1.5pool	17-Jun	4:15			0.05	0.2	0.4	1.3	4.4		lab 6/18, am	
1.5pool	17-Jun	10:15			0.1	0.15	0.5	1.3	4.3		lab 6/18, am	
1.5pool	17-Jun	16:15			0.05	0.15	0.45	1.25	4.1		lab 6/18, am	
1.5pool	17-Jun	22:15				0.15	0.45	1.2	4		lab 6/18, am	
1.5pool	18-Jun	4:15				0.15	0.4	1.2	3.7		lab 6/18, am	
1.5pool	18-Jun	10:15		0.05	0.05	0.1	0.4	1	3.2		lab 6/18, am	
1.5pool	18-Jun	16:15					0.35	1	3.4		lab 6/18, am	floats

*All samples were collected in a 4 ounce plastic container.

Table 7. Phase II. Grab Sample Results. June 2001.
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

			Fluorometer (relative fluorescence units)									
			Fluorometer x1				Fluorometer x100					
Sample Location	Date	Time	xmin..	x3.16	x10	x31.6	xmin.	x3.16	x10	x31.6	Lab Date	Notes
above injection point, 3"pipe, #4	7-Jun	14:30					0.05	0.15	0.3	1.1	lab 6/12, 14:46	
dye injection point	11-Jun	15:30					0.05	0.1	0.4	1.25	lab 6/13, pm	
spring at ore bin,#3	7-Jun	14:30					0.1	0.15	0.4	1.3	lab 6/12, 14:46	
spring above ore bin	11-Jun	15:40	0.1	0.1	0.25	0.7	2.35	7.1	off	off	lab 6/13, pm	
in stream at ore bin,#2	7-Jun	14:30					0.05	0.15	0.4	1.25	lab 6/12, 14:46	
discharge pipe at ore-bin pool	8-Jun	15:30	0.25	0.55	1.8	5.65	off	off	off	off	lab 6/13,11:54	L. Spangler sampled.
seep adjacent to ore bin.	8-Jun	15:35	0.05	0.15	0.3	0.9	2.7	8.3	off	off	ND	L. Spangler sampled.
below tpole/pool in stream	22-Jun	11:30						0.6	1.8	5.7	lab 6/22	var. 5.4-6
below tpole/pool in stream	14-Jun	13:30					0.15	0.3	0.9	2.7	lab 11:47	grab sample, A. Tillia
in stream at tpole	22-Jun	11:30					0.25	0.7	2.3	7	lab 6/22, pm	
Seep 2, Phase I	11-Jun	16:00					0.1	0.15	0.45	1.3	lab 6/13, pm	
Seep 3, Phase I	11-Jun	16:00					0.1	0.1	0.4	1.2	lab 6/13, pm	
Seep 4, Phase I	11-Jun	16:00					0.1	0.15	0.35	1.2	lab 6/13, pm	
spring discharge (toe?)	11-Jun	15:45	0.1	0.15	0.25	0.8	2.5	7.5	off	off	lab 6/13, pm	L. Spangler sampled.
spring discharge (toe?)	8-Jun	15:30	0.3	0.8	2.55	8	off	off	off	off	lab 6/13--11:54	L.Spangler sampled.

All samples were collected in a 4 ounce plastic container.
ND = No Data.

Table 8. Phase II: Data Summary, June 2001.
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	[illegible]						
Sample Location [illegible]	background [illegible]	[illegible] dye arrival [illegible]	peak [illegible]	return to background	Number of samples collected	Date/Time Sampling [illegible]	[illegible] distance from [illegible] (feet)
OB: [illegible]	0.04 ppb First Sample: 6/7, 14:30	0.1 ppb 6/8, 1:25	20 ppb 6/8, 11:25	(not determined, last sample: 7/2, 12:40 with 0.3 ppb)	43	6/7, 14:30 to 7/2, 12:40	750
WP: [illegible] connected to underground [illegible] near the road	0.04 ppb First sample:6/7, 20:05	0.1 ppb 6/9, 18:40	0.2 ppb 6/11, 2:40	0.05 ppb 6/25, 11:25	76	6/7, 20:05 to 7/2, 12:50	1,060
TOE: spring at the bottom of the embankment of mine waste	0.045 ppb First sample: 6/1, 12:00	0.25 ppb 6/8, 18:20	2.2 ppb 6/10, 14:20	(not determined, flow ceased, last sample: 6/16, 14:40 with 1.1 ppb)	74	6/1, 12:00 to 6/16, 14:40	2,290
PP: seeps [illegible] upstream side of the power pole	0.04 ppb First sample: 6/7, 17:15	(not determined)	(not determined)	(not determined, nearly dry: 7/2, 13:05 with 0.2 ppb)	74	6/7, 15:45 to 7/2, 13:05	3,040
P: [illegible] pool in the stream on the [illegible] downstream side of the power pole	0.04 ppb First sample: 6/1, 11:30	(not determined)	(not determined)	(not determined, in stream above dried pool: 6/22, 11:30 with 0.23 ppb)	26	6/1, 11:30 to 6/7, 19:25	3,060
1/2 Pool: pool ~115 feet up from the power pole	(not determined)	0.47 ppb First sample: 6/16, 16:15	(not determined)	(not determined, flow ceased, last sample: 6/18, 18:15 with 0.34 ppb)	9	6/16, 16:15 to 6/18, 16:15	2,750

Notes:
The dye used for the study was 750 ml of Rhodamine WT 20% solution. It was injected in the stream 750 feet above the Ore-bin Pool June 7 at 17:45.
No visible dye was observed at the injection point at 20:00, June 7.
A total of 317 samples were collected. Fifteen of the 317 were grab samples collected at various locations (see data list) June 7 through July 2 (26 days).
First sample collected 6/1, 11:30 and the last sample was collected 7/2, 13:05. Sample locations below the ore bin pool were dry or nearly so by 7/2.
The study included the use of four automatic samplers courtesy of the USGS.
Data gaps in sample collection are attributed to weather conditions, equipment operations, and field work schedules.
The medium for the dye trace pathway varied from natural formations, mine waste, ski run construction, to artificial (altered) stream channels.
The total distance from the dye injection point to the lowest sample location was 3,060 feet.

Table 9. Phase II: Water Data by Date and Time, June 2001.
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah

Date	Time	Location	pH	Conductivity (mS/cm)	Temp (°C)	Dissolved Oxygen (mg/l)
1-Jun	12:25	spring at the TOE sample site	7.80	0.284	4.6	10.41
7-Jun	11:00	Ore-bin Pool sample site	8.50	0.200	5.1	11.58
7-Jun	11:00	in stream 50 feet above OP	7.70	0.240	6.1	ND
7-Jun	11:00	spring adjacent to ore bin	7.50	0.240	4.7	13.50
7-Jun	11:00	in stream at ore bin	7.70	0.233	5.0	10.50
7-Jun	11:00	spring adjacent to ore bin	7.70	0.220	4.7	13.00
7-Jun	11:00	discharge from 4 inch pipe above dye injection point.	8.20	0.196	3.9	13.80
7-Jun	11:00	in stream above 4-inch pipe	8.10	0.224	7.0	11.22
7-Jun	15:00	TOE spring	8.00	0.280	5.0	15.00
7-Jun	15:00	White Pipe sample site	7.00	0.315	5.2	13.50
7-Jun	18:55	Power Pole sample site	7.20	0.430	6.7	13.50
7-Jun	18:55	P-str (pool-in-the-stream) sample site	11.6*	0.340	6.9	10.00
7-Jun	18:55	northern seep near 1/2 pool	11.00*	0.350	5.3	13.25
7-Jun	18:55	in stream near seep, near 1/2 pool	11.00*	0.312	7.0	12.00
7-Jun	18:55	southern seep near 1/2 pool	10.8*	0.315	4.6	13.50

Notes:
ND = No Data.
*The anomalous pH values may be attributed to a miscalibration of the instrument.

Table 10. Fluorometer Calibration for Rhodamine WT
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI. Summit County, Utah

Phase I

1.0 ppb	.001ppm	= 0.1 @ x1x min
10.0 ppb	0.01 ppm	= 1.0 @ x1 x min
100 ppb	0.1 ppm	= 10.0 @ x1 x min
1.0 ppb	0.001 ppm	= 1.0 @ x1 x10
10.0 ppb	0.01 ppm	= 10.0 @ x1 x10
0.1 ppb	0.0001 ppm	= 1.0 @ x100 x min
1.0 ppb	0.001 ppm	= 10.0 @ x100 x min
0.01 ppb	0.00001 ppm	= 1.0 @ x100 x 10
0.1 ppb	0.0001 ppm	= 10.0 @ x100 x 10

(Lower Sampler: background, 0.7: 0.007 ppb @ x100 x10)

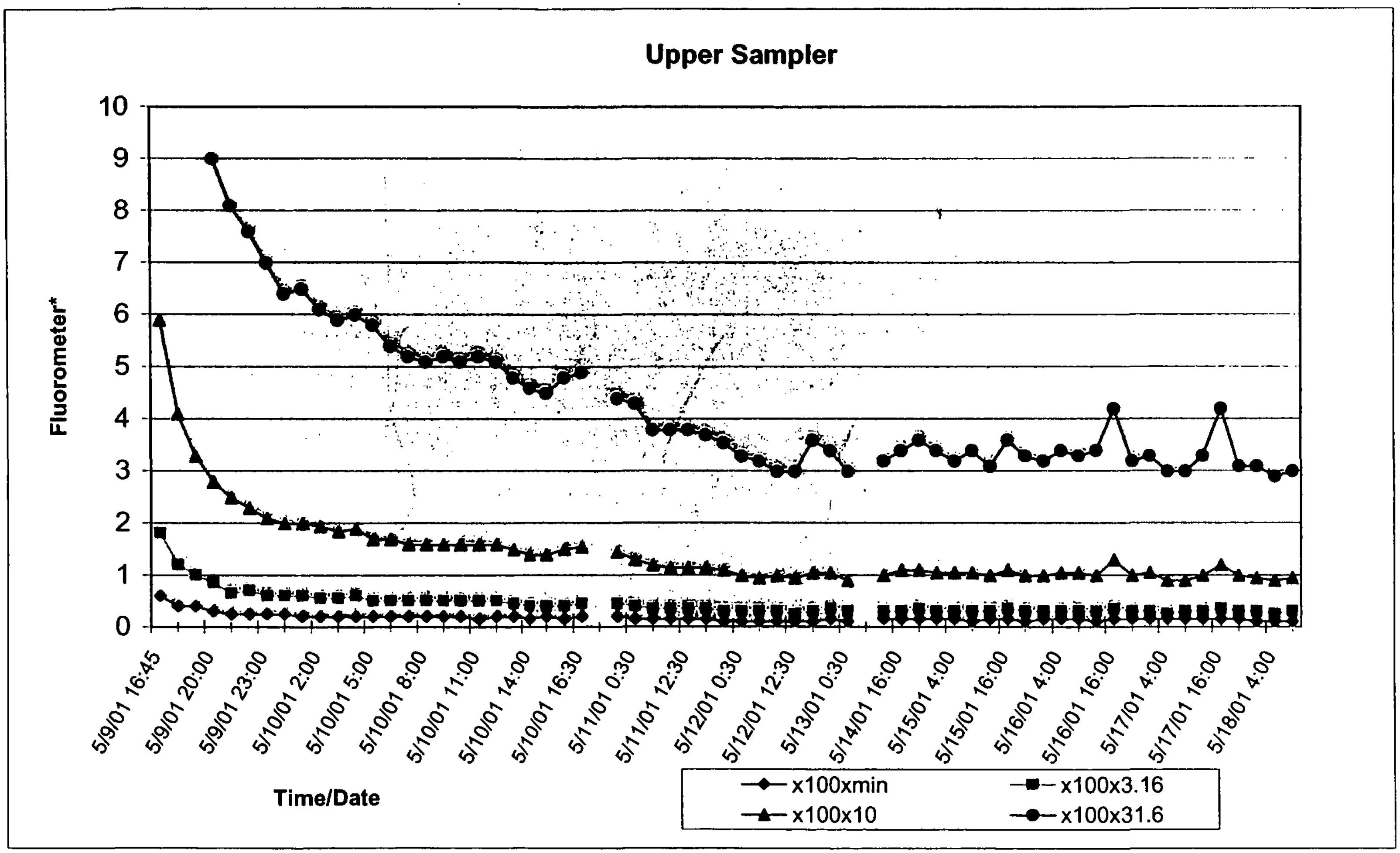
Phase II

100 ppb	0.1 ppm	= 1.0 @ x1 x min
1000 ppb	1.0 ppm	= 10.0 @ x1 x min
10 ppb	0.01 ppm	= 1.0 @ x1 x 10
100 ppb	0.1 ppm	= 10.0 @ x1 x 10
1.0 ppb	0.001 ppm	= 1.0 @ x100 x min
10.0 ppb	0.01 ppm	= 10.0 @ x100 x min
0.1 ppb	0.0001 ppm	= 1.0 @ x100 x 10
1.0 ppb	0.001 ppm	= 10.0 @ x100 x10

(P-str Background, 0.4: 0.04 ppb @ x100 x10)

CHARTS

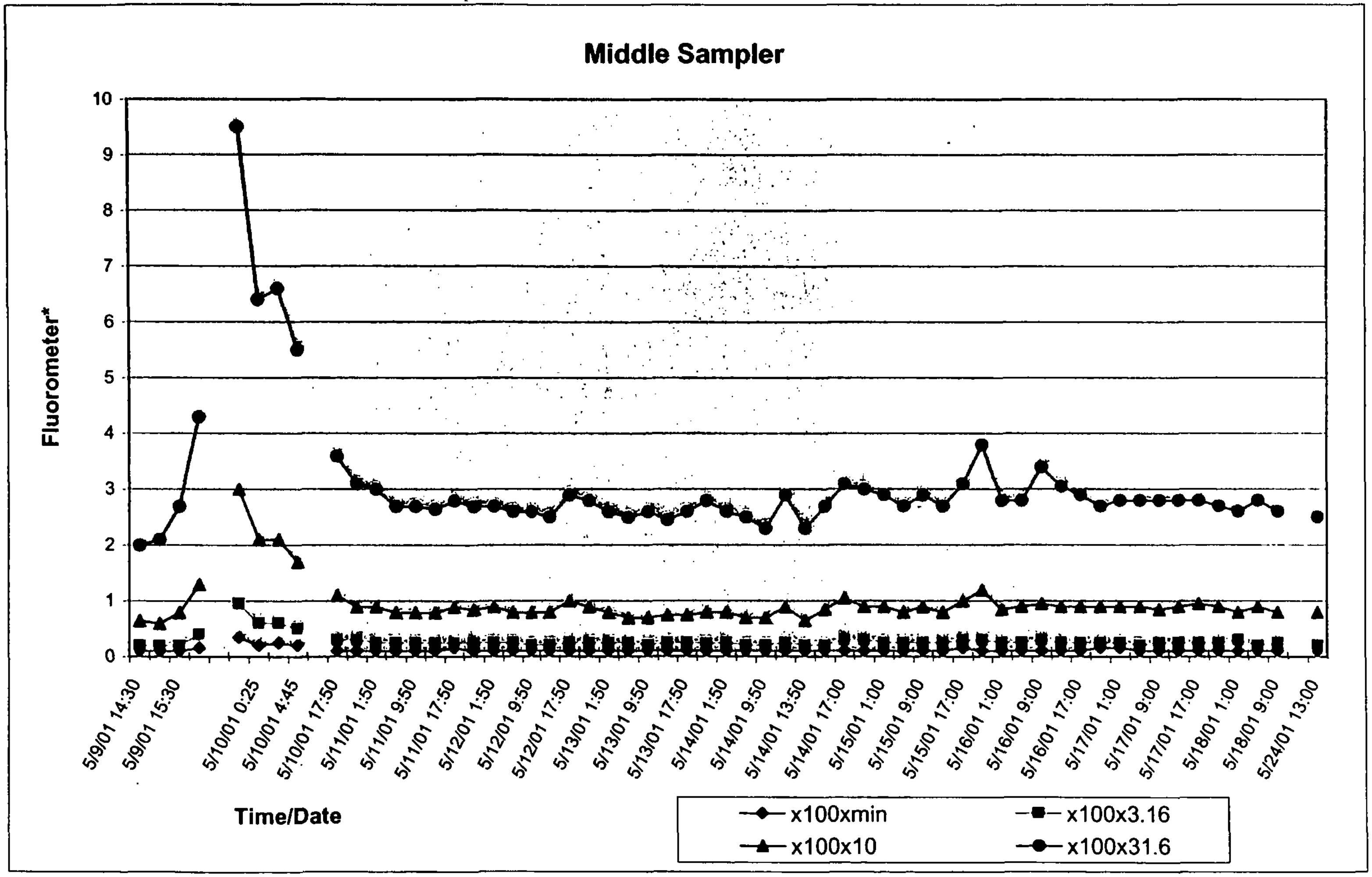
Chart 1. Phase I: Upper Sampler Results, May 2001.
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah



Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 1. Phase I: Upper Sampler Results, May 2001.

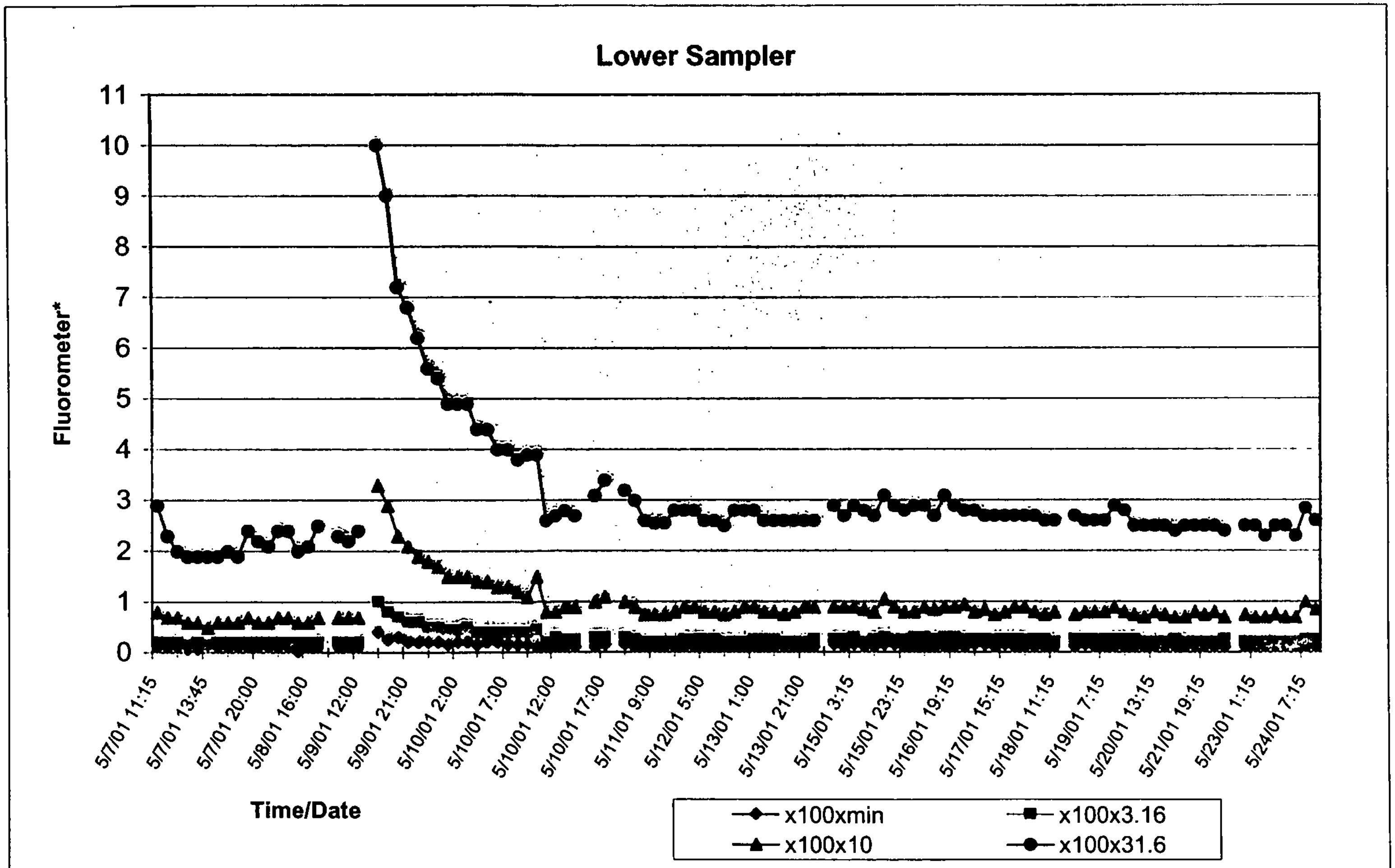
Chart 2. Phase I: Middle Sampler Results, May 2001.
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah



Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 2. Phase I: Middle Sampler Results

Chart 3. Phase I: Lower Sampler Results, May 2001.
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah



Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 3. Phase I: Lower Sampler Results, May 2001.

Chart 4. Phase I: Seep 1Sample Results, May 2001.
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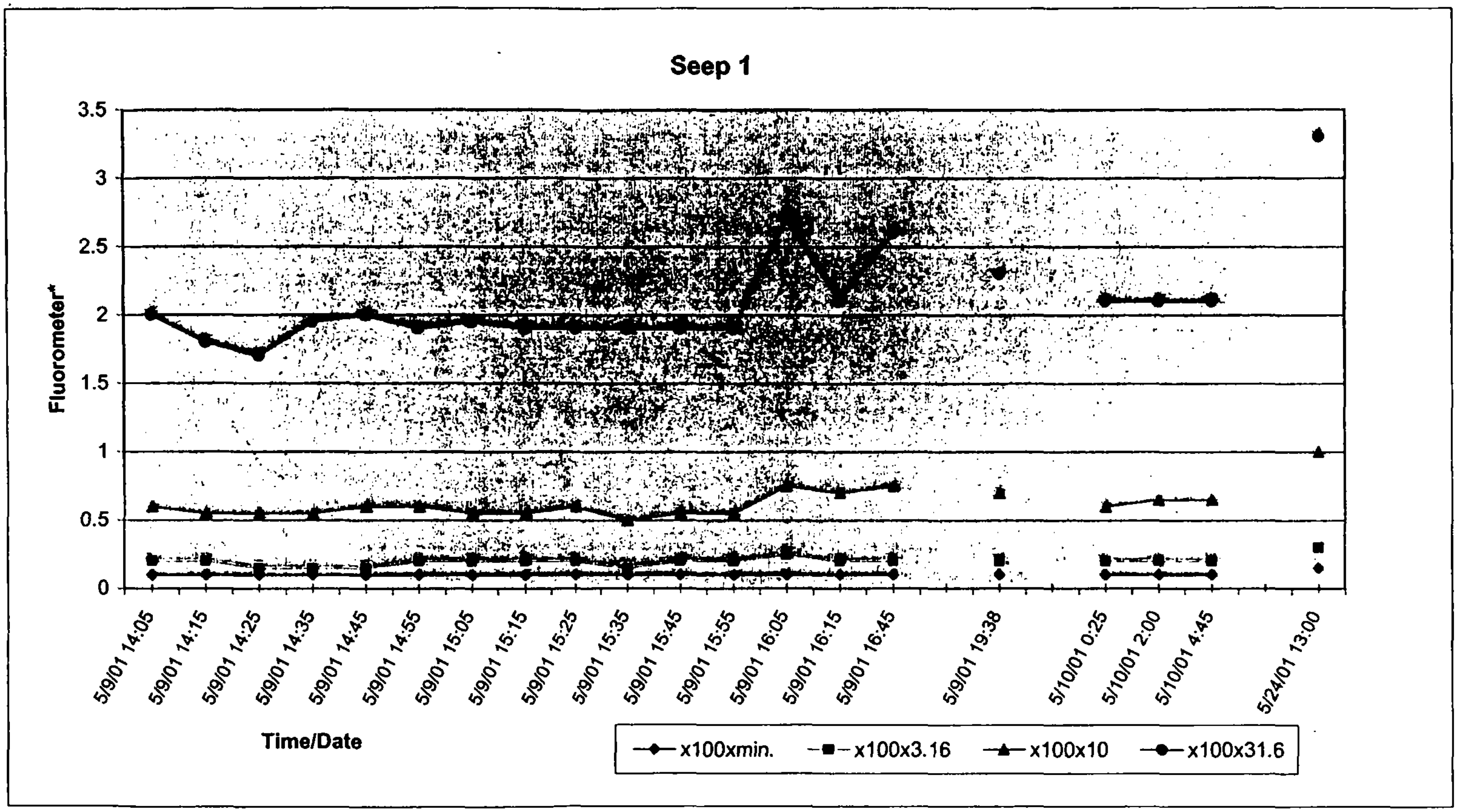
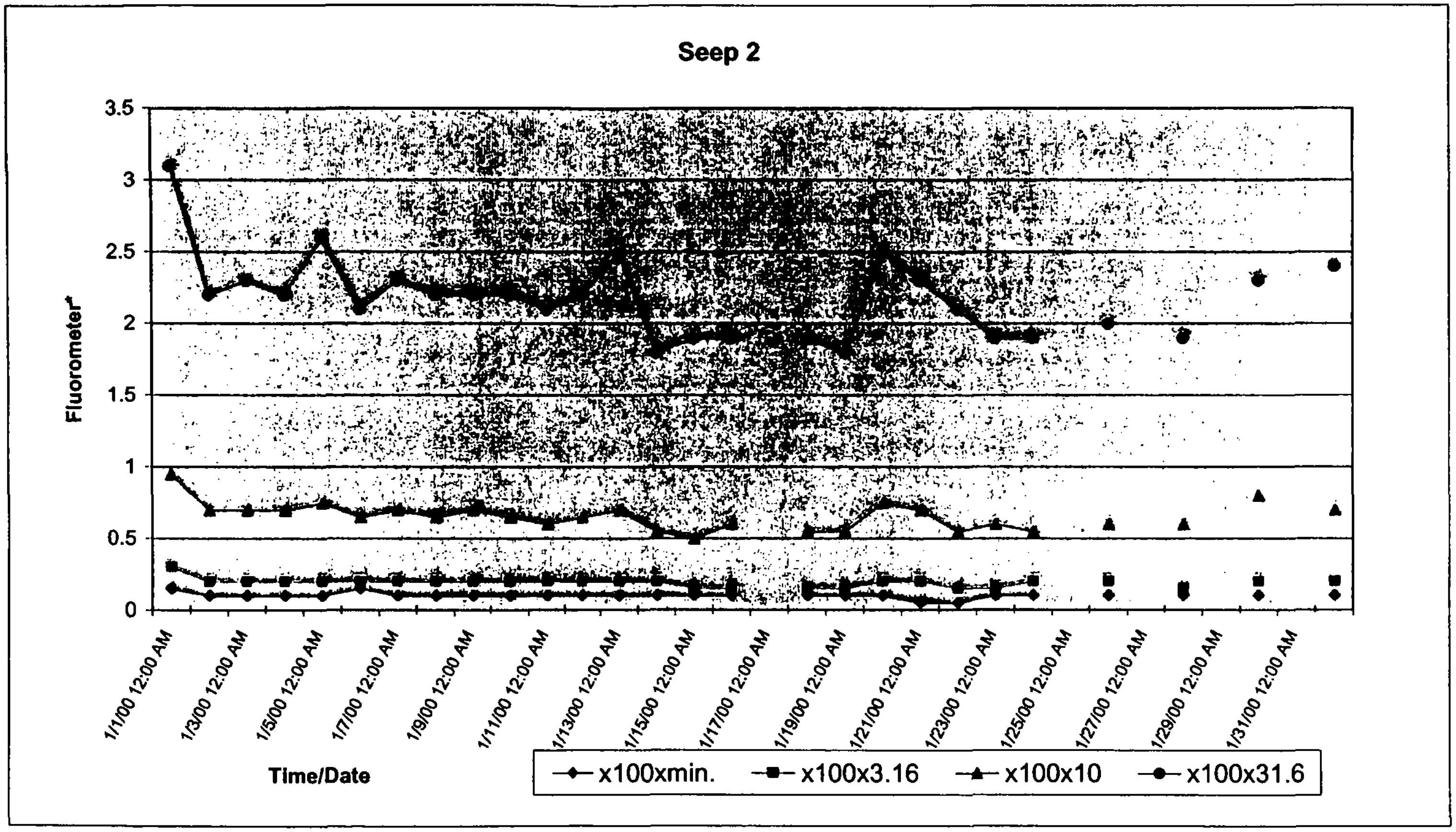
UDEQ/DERR Empire Canyon ESI, Summit County, Utah



Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 4. Phase I: Seep 1Sample Results

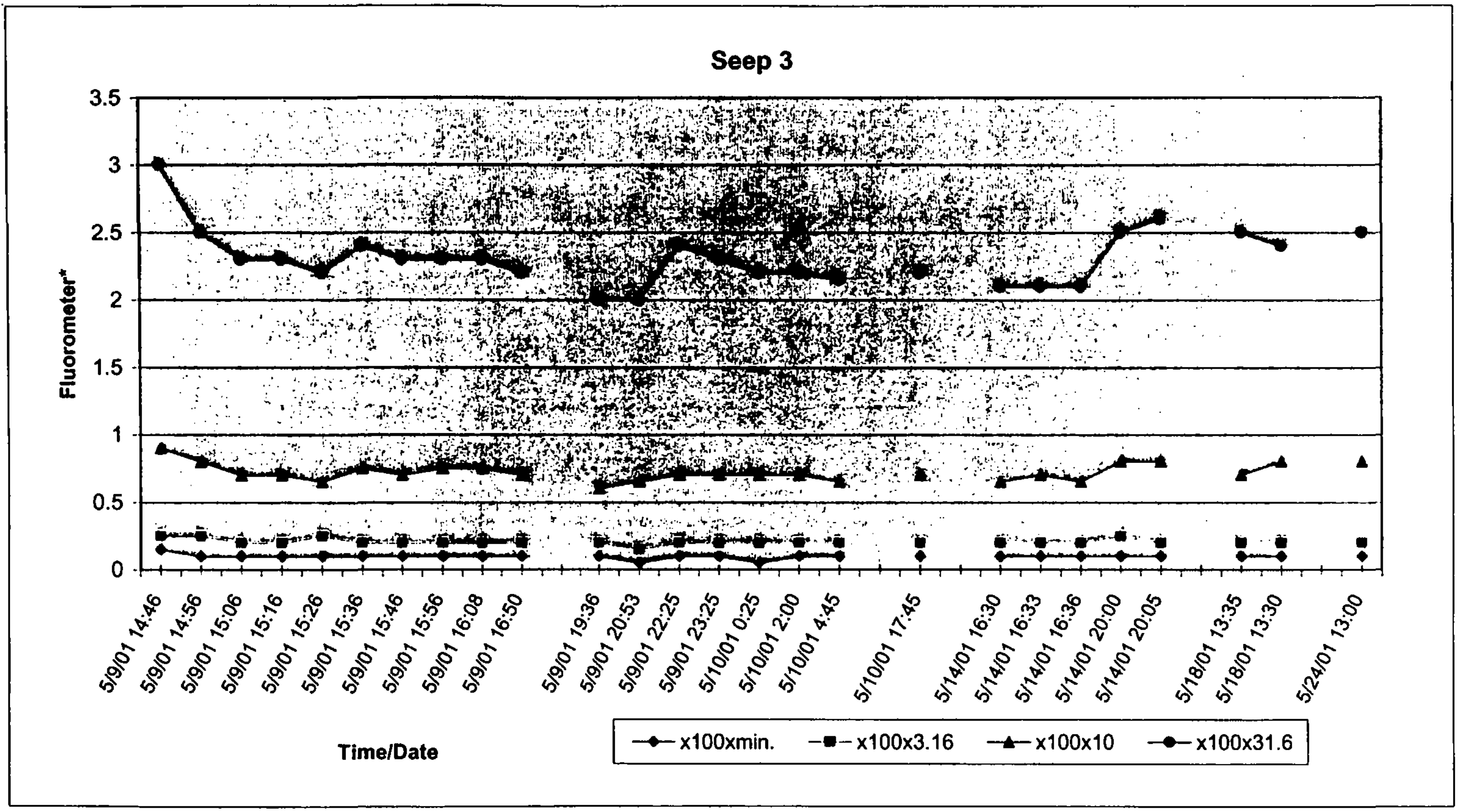
Chart 5. Phase I: Seep 2 Sample Results, May 2001.
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah



Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 5. Phase I: Seep 2 Sample Results

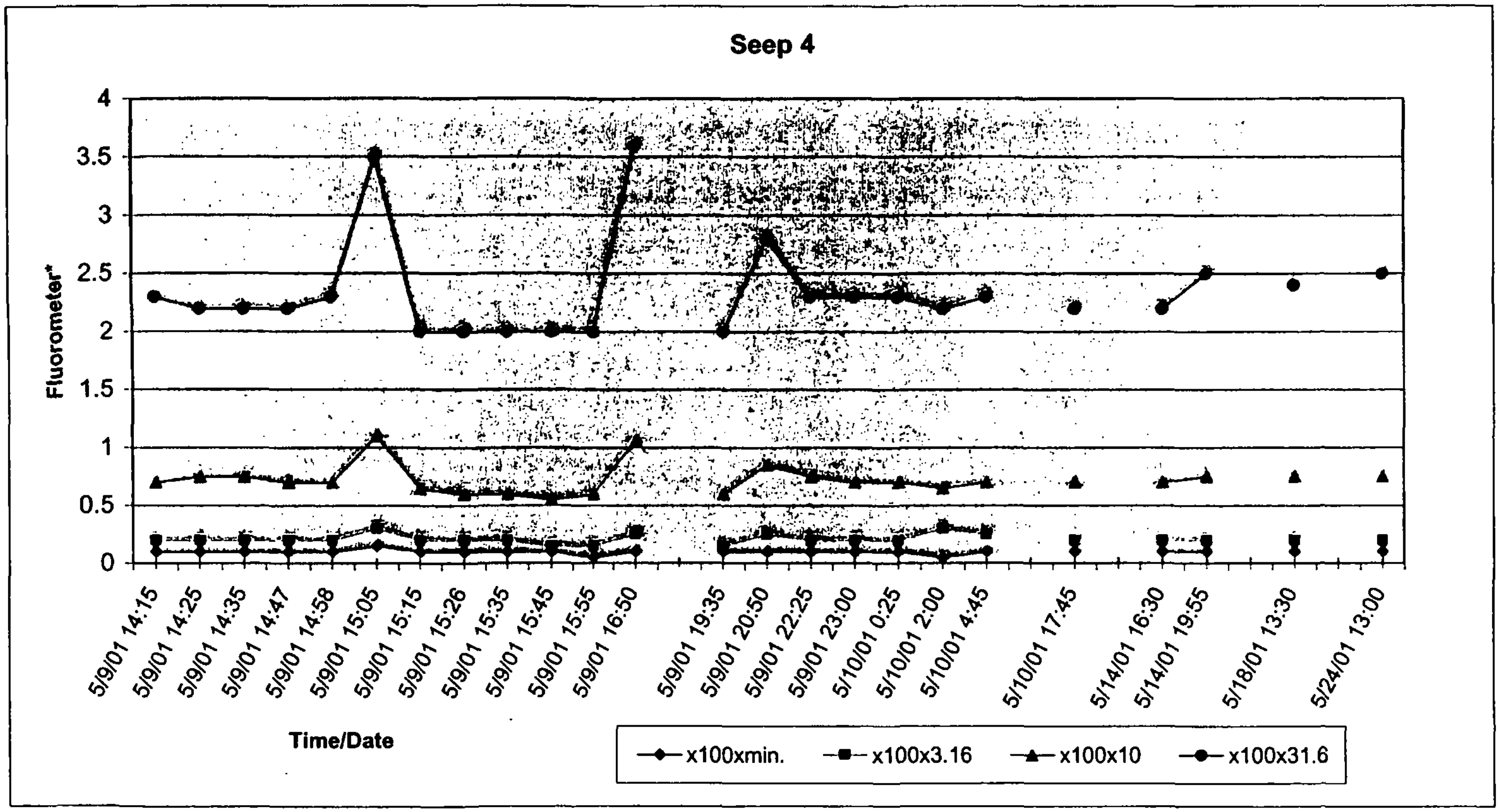
Chart 6. Phase I: Seep 3 Sample Results, May 2001.
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah



Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 6. Phase I: Seep 3 Sample Results

Chart 7. Phase I: Seep 4 Sample Results, May 2001.
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah



Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 7. Phase I: Seep 4 Sample Results

Chart 8. Phase II: Ore-bin Pool Sample Results, May 2001.
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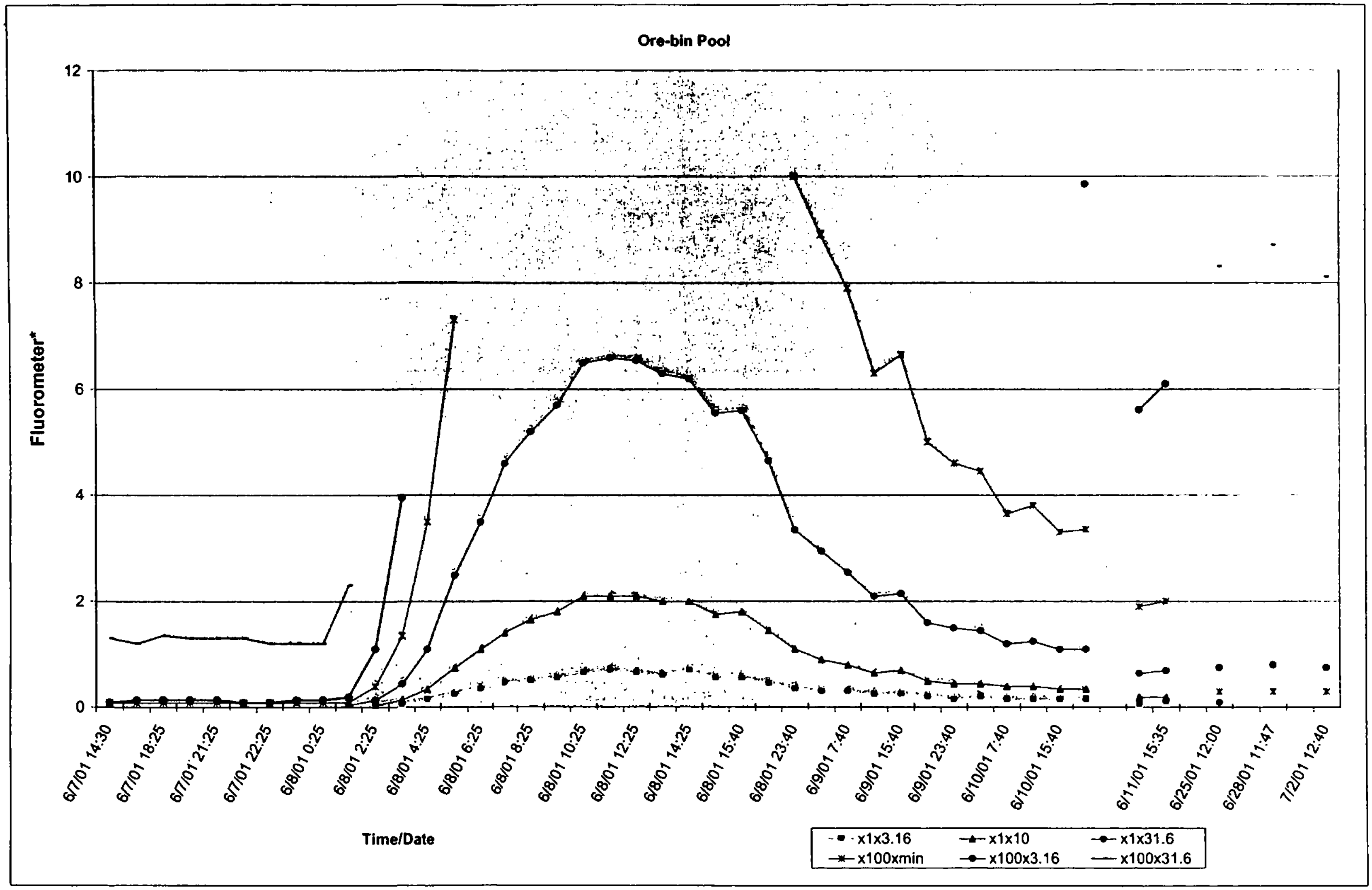

Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 8. Phase II: Ore-bin Pool Sample Results

Chart 9. Phase II: White Pipe Sample Results, May 2001.
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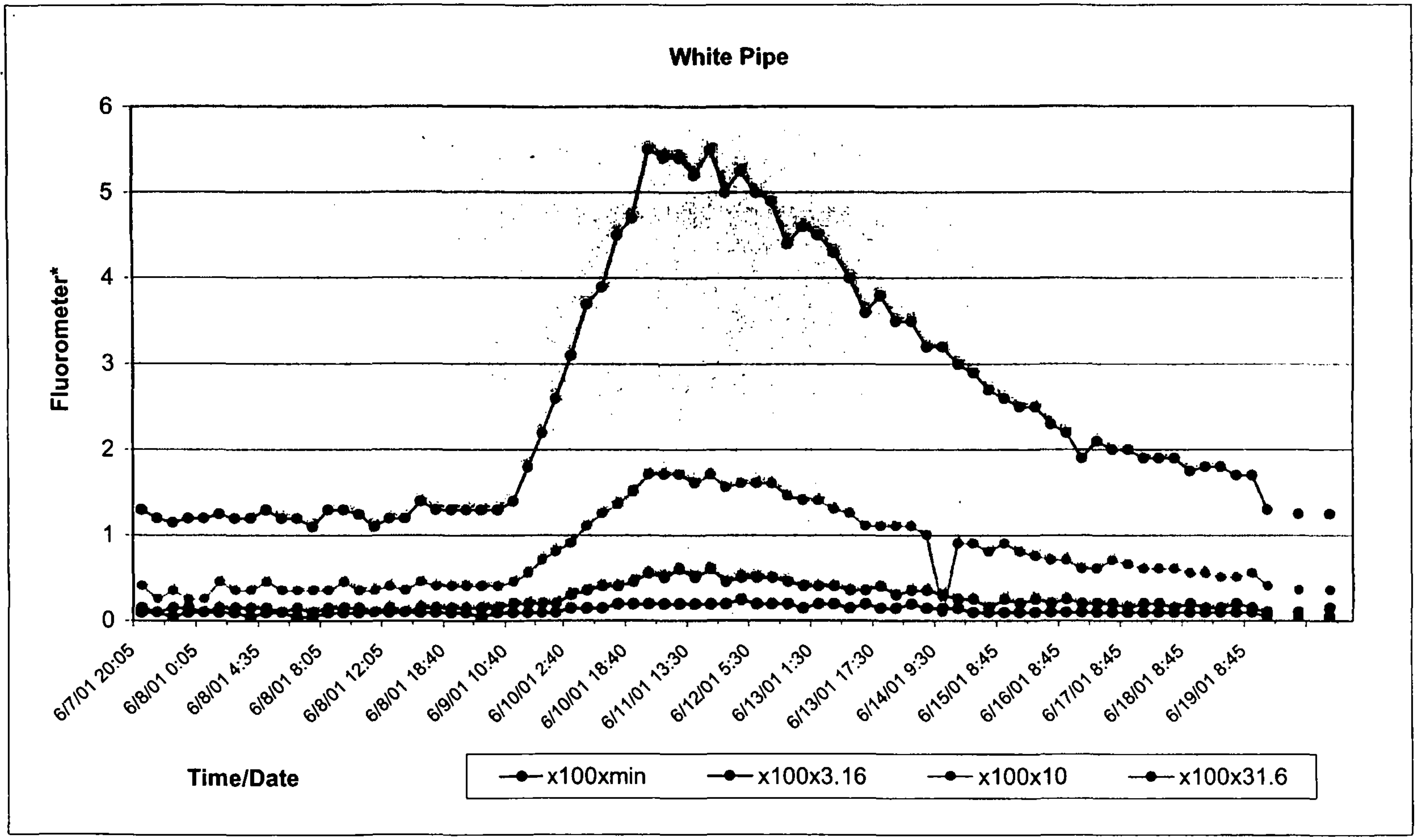
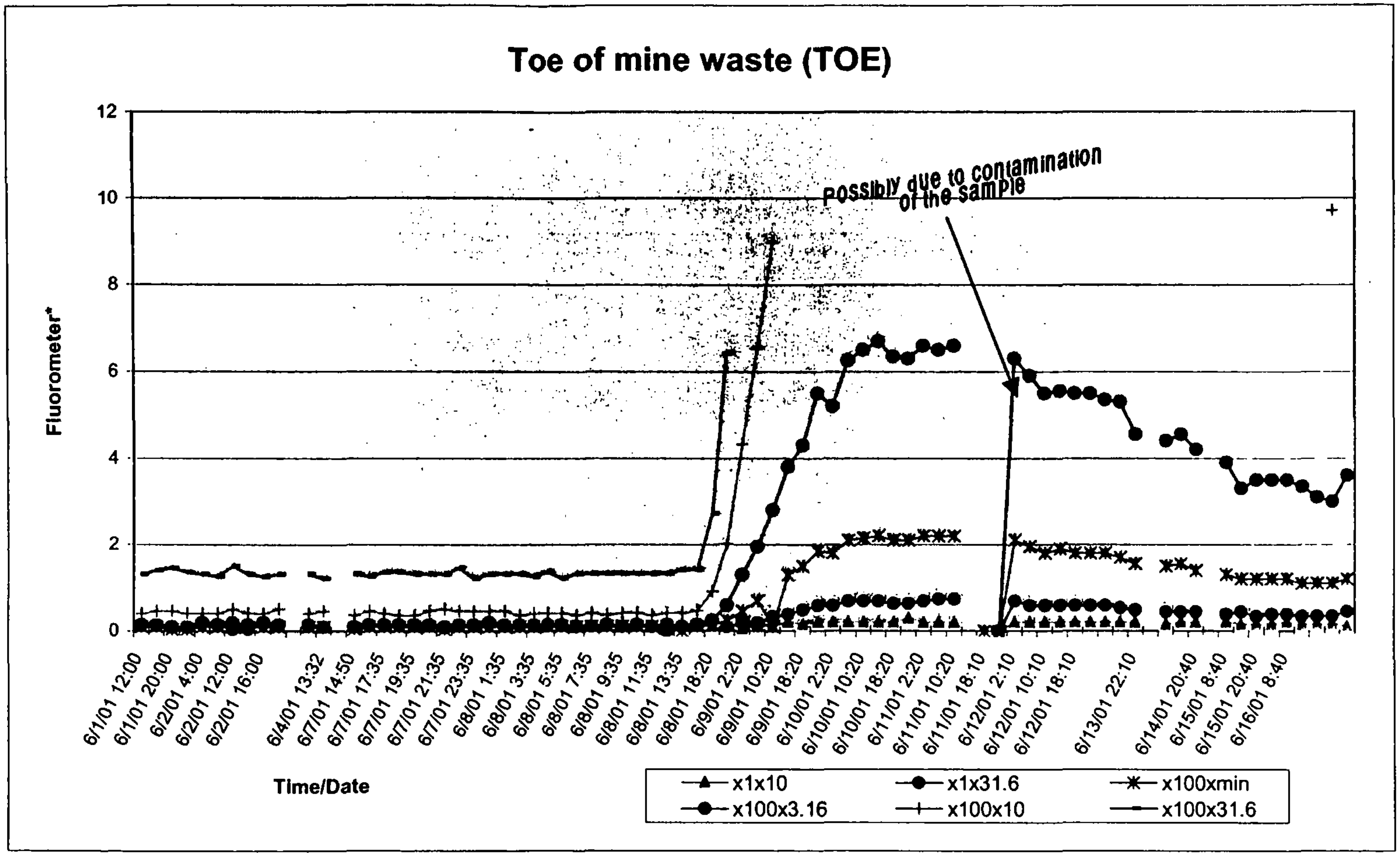
UDEQ/DERR Empire Canyon ESI, Summit County, Utah



Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 9. Phase II: White Pipe Sample Results

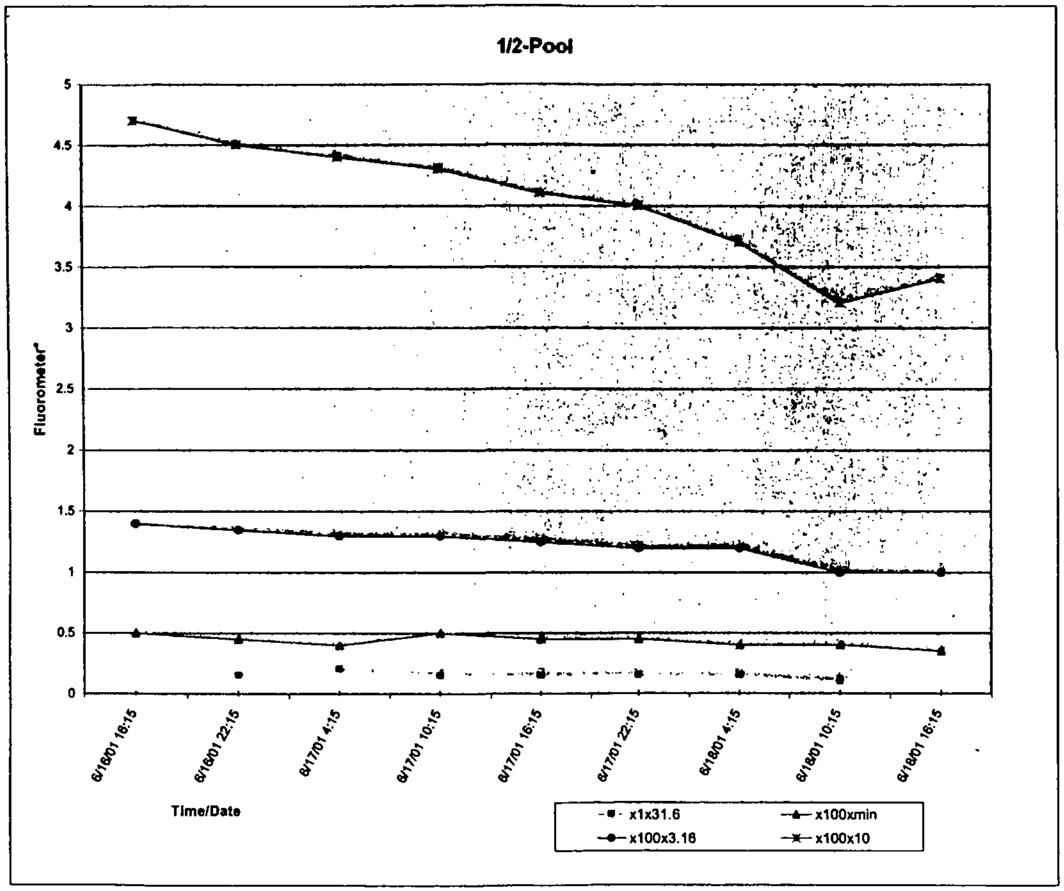
Chart 10. Phase II: TOE Sample Results, May 2001.
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah



Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 10. Phase II: TOE Sample Results

Chart 11. Phase II: 1/2-Pool Sample Results, May 2001.
Tracer Study Results Report
UDEQ/DERR Empire Canyon ESI, Summit County, Utah



Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 11. Phase II: 1/2-Pool Sample Results

Chart 12. Phase II: Power Pole Sample Results, May 2001.
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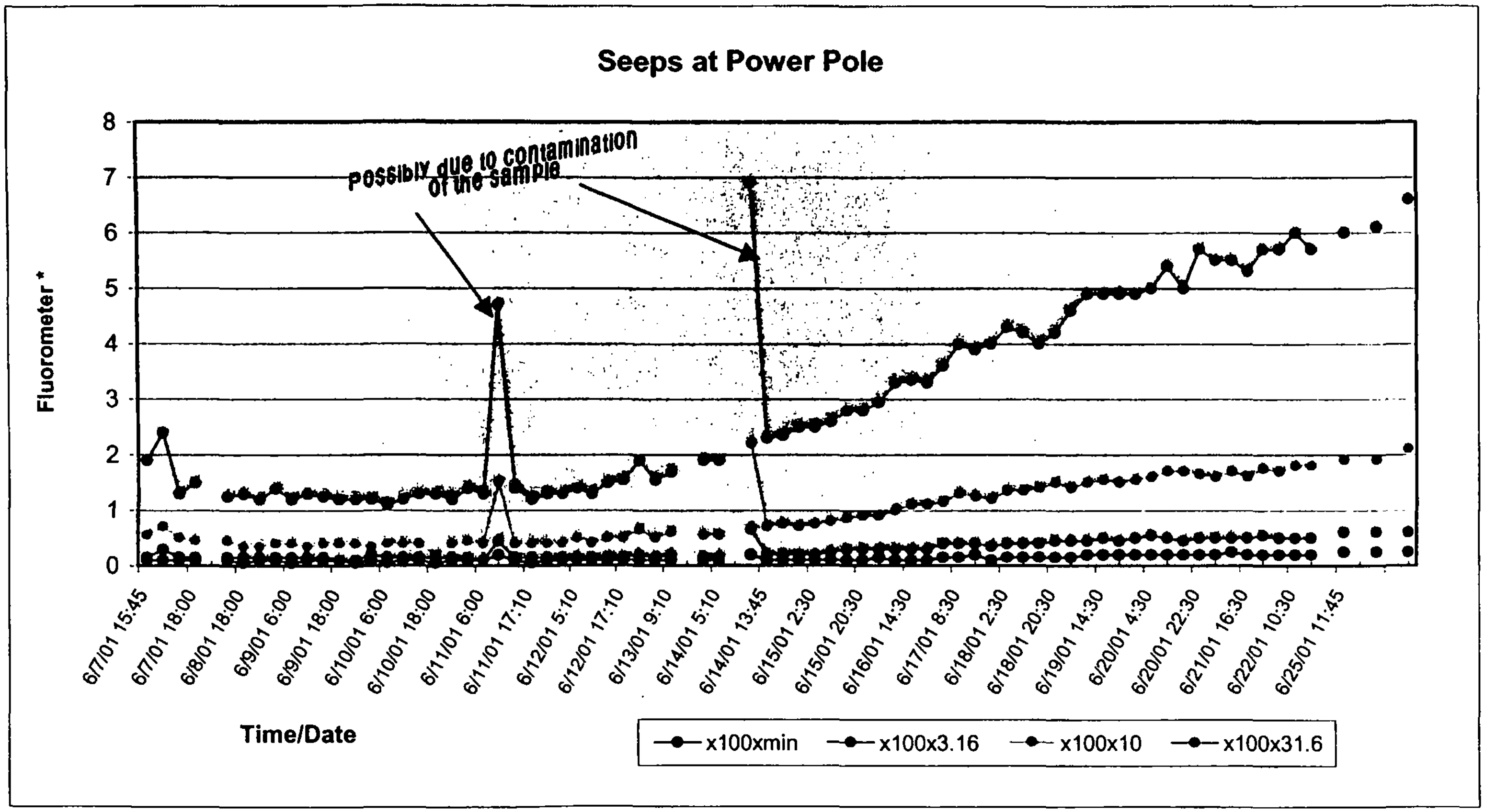
UDEQ/DERR Empire Canyon ESI, Summit County, Utah



Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 12. Phase II: Power Pole Sample Results

Chart 13. Phase II: Pool-in-the-stream (P-str) Sample Results, May 2001.
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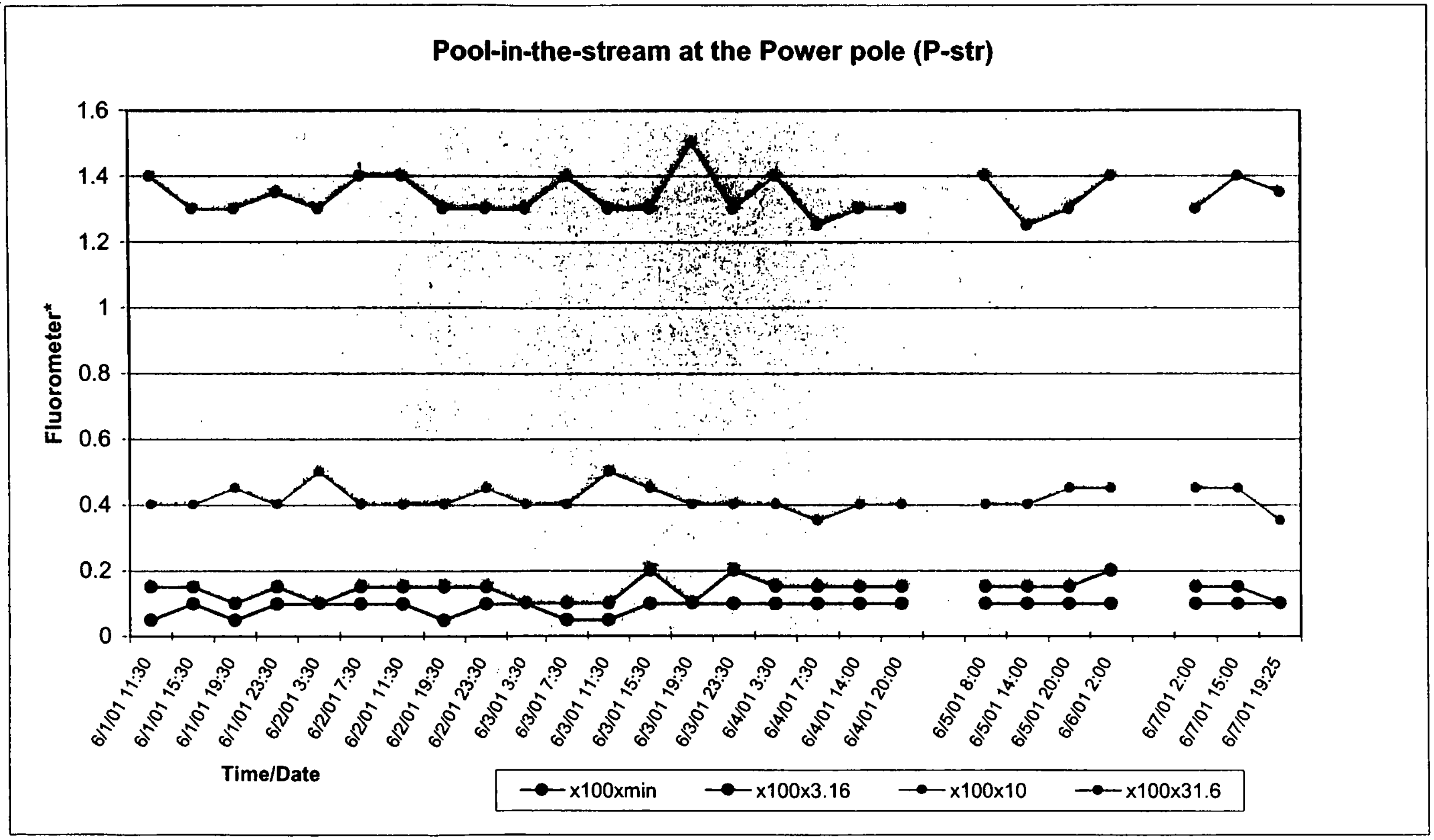
UDEQ/DERR Empire Canyon ESI, Summit County, Utah



Note: Data gaps are attributed to weather conditions, equipment operations, and fieldwork schedules.
*Fluorometer readings are relative fluoroscence units.

Chart 13. Phase II: Pool-in-the-stream Sample Results

APPENDIX A

Photos:
Phase I: L1 - L5
Phase II: U1 - U16

Poor Quality Source Document

The following document images have been scanned from the best available source copy.

To view the actual hard copy, contact the Superfund Records Center at (303) 312-6473.

Photo L1 shows Seep 1 and the Middle Sampler sampling site. The seep, indicated by the arrow, is under a boulder, as shown by the dashed line. The Middle Sampler probe collected samples from the stream above the boulder. This sample location is 1,750 feet downstream from the dye injection point.

Photo L2 shows the flow from the Seep 2 sampling site emerging from the bank at stream level. A trail of moss from the seep/spring is shown in this photo. The distance from the dye injection point to Seep 2 is 1,825 feet.

Photo L3, is a view the Seep 3 sample site (dry in this photo), from which several seeps flowed as the run-off peaked. Samples were collected from the largest seep as indicated by the arrow.

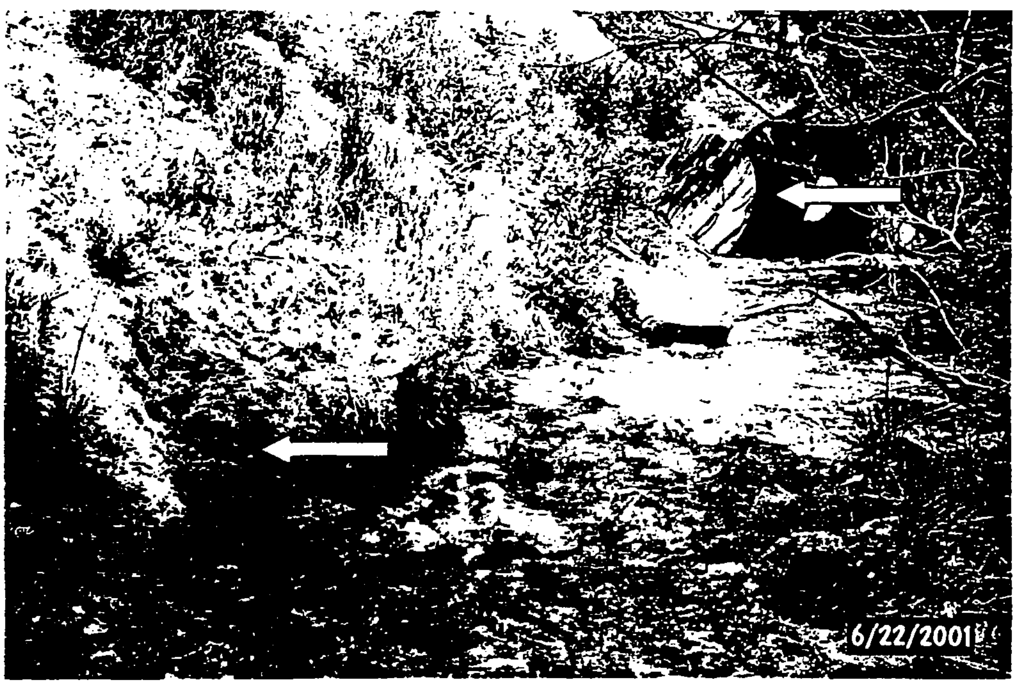


Photo L4, shows Seep 4, which emerged from the west bank 10 inches above the stream (lower arrow). The distance from the dye injection point to Seep 4 is 1,920 feet. The Lower Sampler was camouflaged behind the large spools on the west side of the stream 50 feet downstream of Seep 4.

Photo L5 shows the Phase I dye introduction point in the stream above the culvert and adjacent to the dirt road and historical mine buildings. The dye, 250 ml of Rhodamine WT, was poured in to the stream May 7 at 14:05. Photo courtesy of Larry Spangler, USGS.

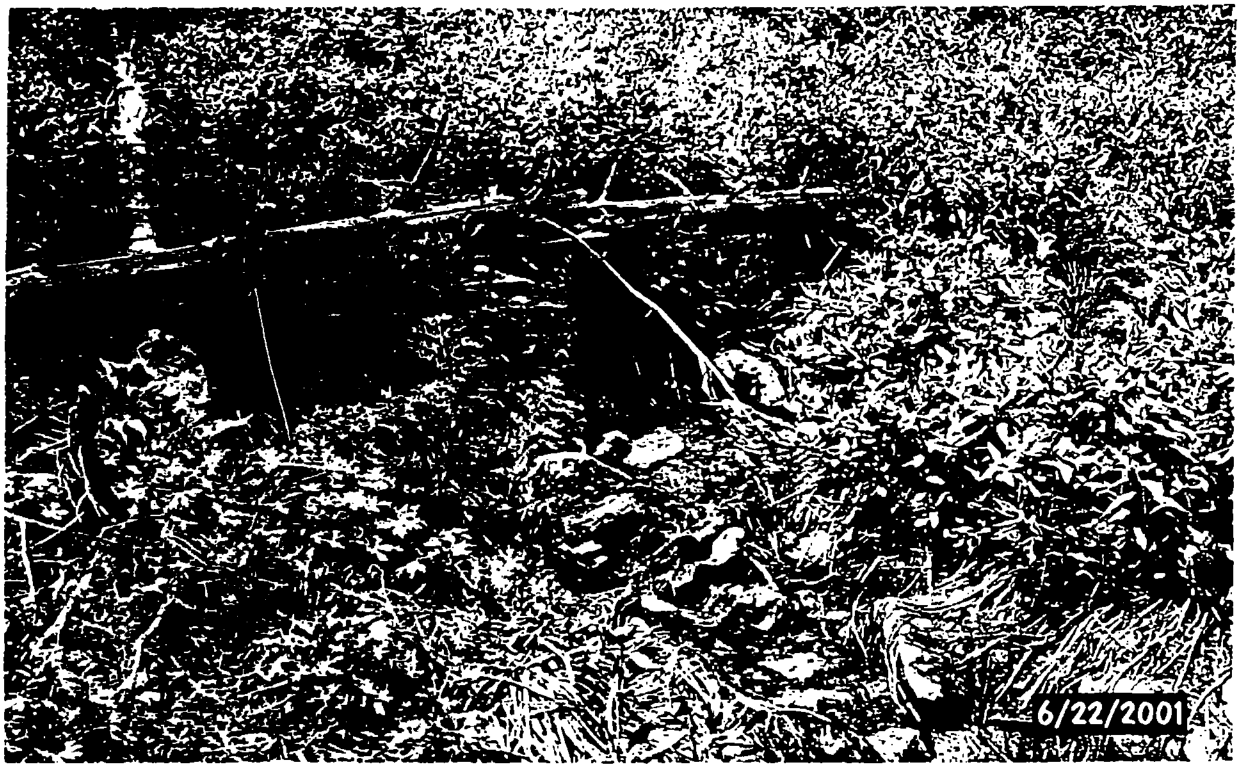


Photo U1 shows the Phase II dye injection point in which 750 ml of Rhodamine WT dye was poured into the stream channel on June 7, 2001. The dye injection point is 545 feet upstream of the Ore-bin Pool. The stream channel down to the Ore-bin Pool site is a natural, unlined ephemeral stream channel filled with cobbles and some fallen trees (as a result of selective forest thinning done by the ski resort). The surface water disappears in the stream channel under a pile of tree branches approximately 50 feet downstream of the dye injection point.

Photo U2 is a view upstream of the Ore-bin Pool sample site, which lies approximately 500 feet downstream from the dye injection point. The top of the ore bin is seen in the upper right corner. To the right of the fallen tree are a few logs on which the automated sampler was located (see arrow). A storm with high winds blew a tree down the night of June 12, destroying the sampler. Surface flow in the stream channel above the pool is intermittent. A significant flow of water emerges from a two-inch PCV pipe located under the logs, which supported the sampler. The day after the dye was injected, the water discharging from the PCV pipe was noticeably tinted with dye.

Photo U3 shows the stream below the Ore-bin Pool. The stream disappears approximately 20 feet below the pool and does not enter the first culvert. Surface flow is significantly less below the pool compared to the flow at the dye injection point.

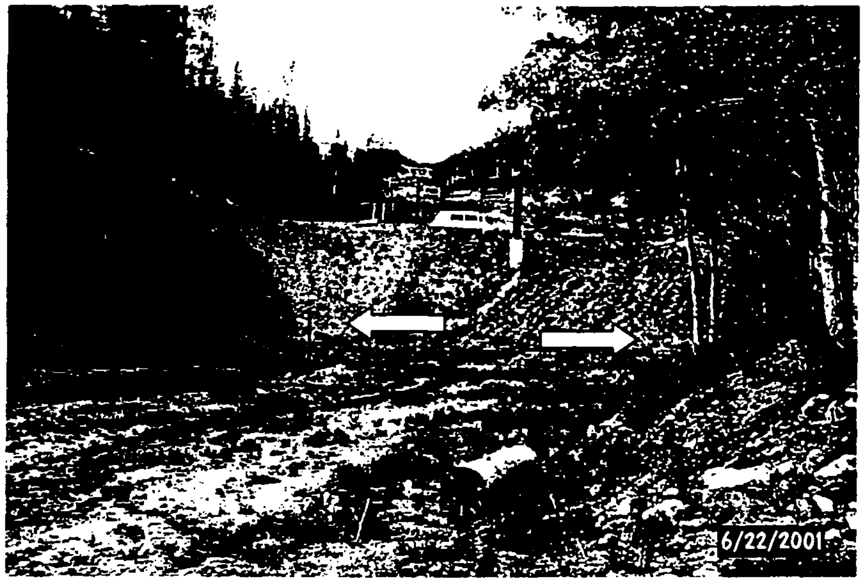


Photo U4 shows the upvalley view from the White Pipe sampling site. The McConkie ski lift is the white object in the upper-center of the photo. To the left of the ski lift and in the trees is the Ore-bin Pool sampling site. The approximate distance from the White Pipe to the Ore-bin Pool is 1,500 feet. The arrow on the left indicates a culvert from which little or no water flowed during the study. The arrow on the right indicates the location of a spring at the base of the aspen trees. The aspen spring produced a small quantity of water (approx. 1 gpm) prior to the injection of dye in the system and temporarily flowed later in the study in response to passing rain showers.

Photo U5 of the White Pipe sample site. The hill on the left is mine waste and the flat area below the McConkie ski lift is above the hill. The reworked stream channel curves to the east down to the TOE and then turns northeast downstream to the Power Pole site. It is 580 feet between the White Pipe and the TOE.

Photo U6 is a close up of the White Pipe site. Water flowed from the pipe for the duration of the study, but disappeared into the gravel several feet downstream. The pipe is connected to several upgradient springs that are the remains of a water supply system.

Photo U7 shows the TOE sampling site located at the base of mine waste. A spring (dry in the photo) emerged from the rocks and was the site of the TOE sampler (see arrow). The stream channel from the White Pipe site follows the path of the tall grass and intersects the main channel just below the TOE site, as indicated with the dashed line. The spring at the TOE sampling site produced 300 to 400 gpm at the start of the study and ceased to flow between field site visits on June 14 and 16.

Photo U8 is the TOE sampler location on June 11. The arrow indicates the spring site and the automated sampler is the yellow object below the arrow. On this date the flow from the spring had decreased and rocks were re-arranged to form a pool for the sampler probe. The spring dried up by June 16. Photo courtesy of Larry Spangler, USGS.

Photo U9 is taken from the top of the mine waste looking down Walker-Webster Gulch and shows the TOE sample site in the foreground and the ½-Pool sample site in the background as indicated by the top arrow. The lower arrow indicates the stream channel from the White Pipe sample site. The photo was taken June 11. Photo courtesy of Larry Spangler, USGS.

Photo U10 shows the Phase II ½-Pool sample site in the reworked stream channel between the TOE sample site and the Power Pole sample site. The site of three seeps, which emerged from the east bank, is indicated with arrows. The seep nearest the sampler is shown in Photo U11 and the center seep is shown in Photo U12. On June 19, the stream channel and seeps were dry and the sampler was removed from the site.

Photo U11 shows the seep site closest to the ½-Pool, which emerged from the east bank.

Photo U12 shows the center seep site (see arrow) from Photo U10, which was immediately right of the seep indicated in Photo U11 and upstream of the ½-Pool sample site.

Photo U13.
The automated sampler at the Power Pole site was 15 feet above the power pole on the west bank of the stream (see arrow pointing downstream). A small pool was created so the probe could capture the flow from the seeps before it entered the stream.

Photo U14 shows an upstream view of the Power Pole site. The stream channel is to the left and the seeps are to the right (see arrows). The sampler is located at the most downstream seep, which appeared to produce the highest flow. The exact point from which the seeps emerged was not easily discerned.

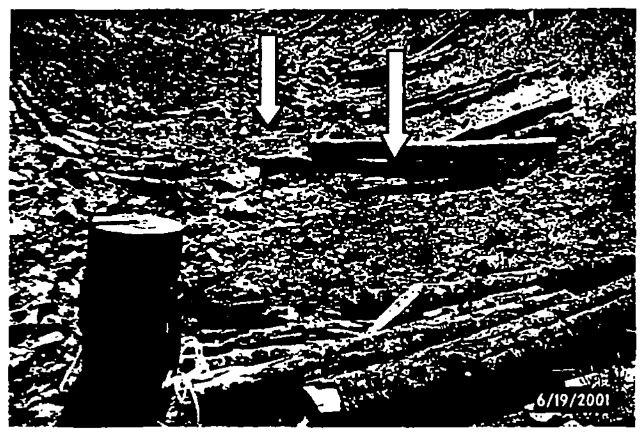


Photo U15 is a view downstream of the Power Pole site, which is left of the lower left corner of the photo. The stream disappeared above the now dry pool, in the center of the photo, and reappeared approximately 10 feet below the dried pool. Samples were collected from the pool between June 1 and June 7. The pool dried up between the June 14 and June 16 field visits. Below the pool site a natural stream channel exists downstream 3,240 feet to the Phase I dye introduction point.

Photo U16, taken June 11, is a view up Walker-Webster Gulch from the Power Pole sampler (PP) in the foreground and to the base of the mine waste (TOE sampler) in the background as indicated by the upper arrow. The lower arrow indicates the ½-Pool sample site and location of the seeps, which emerged from the left (east) bank. The automated sampler is the yellow object adjacent to the stream The seeps emerged from under the logs on the right (west) bank. The power pole is adjacent to the stream immediately left of the photo. Photo courtesy of Larry Spangler, USGS.

Tabbed Page: Appendix B

Applied Geotechnical Engineering Consultants, Inc.

November 6, 2000

DMB
7600 East Doubletree Ranch Road, #300
Scottsdale, Arizona 85258-2137

Attention: Michael J. Roberts

Subject: Building Setback, Pad A
Flagstaff Mountain Resort
Park City, Utah
Project No. 1000208D

Gentlemen:

Applied Geotechnical Engineering Consultants, Inc. was requested to evaluate slope stability concerns and provide building setback, where appropriate, from the steep slope on the north side of the proposed Flagstaff Mountain Resort which is located south of Park City, Utah (see Figure 1). We previously performed a geologic and geotechnical investigation for Pod A of the proposed Flagstaff Mountain Resort and submitted our findings and recommendations in a report dated August 11, 2000 under Project No. 1000208D. We also investigated a landslide and provided building setbacks based on the information obtained at the time of the investigation in a letter dated September 5, 2000 under Project No. 1000208D.

SCOPE OF STUDY

This study was performed to refine th building setback criteria for the areas proposed for development located south and southwest of the landslide. The study included:

- Field mapping the existing landslide.
- Drilling two borings above the landslide.
- Drilling 2 borings along the upper portion of the steep slope southwest of the landslide.
- Testing samples of the materials for their strength characteristics.
- Developing profiles of the areas of the existing landslide.

600 West Sandy Parkway • Sandy, Utah 84070 • (801) 566-6399 • FAX (801) 566-6493

- Developing profiles for adjacent areas to the northeast and southwest from existing contour maps.
- Performing stability analysis of the landslide and adjacent areas.

HISTORY OF LANDSLIDE

Aerial photographs of the site and vicinity were reviewed during our evaluation of the landslide. These photographs were dated July 3, 1953; May 20, 1966 and October 20, 1989. A profile, which portrays the ground surface through the landslide prior to and just after the landslide occurred was provided by United Park City Mines. The profile is dated June 1, 1967.

A review of the aerial photographs indicate that three roads had been cut across the area of the present day landslide by 1953. Material was removed from the toe of the slope in the area of the landslide by 1966. We understand that removal of the material at the toe of the slope was part of mining operations occurring in the area. A rough estimate, based on the available contour maps, suggests that approximately 40,000 cubic yards of material had been removed from the toe of the slope prior to the landslide occurrence.

Records suggest that the failure of the slope occurred in the Spring of 1966. Kerry Gee of United Park City Mines indicated that approximately 3 days of heavy rain occurred prior to failure of the slope. Slide failure occurred at a relatively rapid rate and the toe of the slide temporarily blocked the drainage.

A comparison of the profile for the landslide just after the slope failure and a profile based on the 1989 contour map indicate that the head of the landslide has migrated upslope a distance of approximately 135 feet to its present day location. Figure 6 presents a profile of the ground surface prior to development of the landslide. This figure also shows the approximate area excavated at the toe of the slope. Figure 7 presents a profile of the slope just after the landslide occurred and Figure 8 presents the 1989 profile of the slope through the landslide. The location of the profiles is presented on Figure 2.

Continued ravelling of the slope appears to be occurring. This ravelling is generally being limited by the more resistant underlying bedrock at the site.

SITE CONDITIONS

Our field reconnaissance of the area indicates the slide exposes predominantly bedrock consisting of highly fractured quartzite. The rock is faulted and has zones along the faults which were hydrothermally altered. Some fractures are infilled with clay.

The slopes which are actively sluffing form slopes on the order of 38 degrees from horizontal. The slopes in bedrock range from approximately 45 degrees to near vertical.

The overburden, which is silty to clayey sand and gravel, is typically 4 to 5 feet thick. It is thickest at the upper end of the slide, where it is estimated to be approximately 40 feet thick along the slope of the slide, or approximately 30 feet in vertical thickness.

SUBSURFACE CONDITIONS

Four borings were drilled at the approximate locations indicated on Figure 2 to observe the subsurface profile, to obtain samples of the subsurface material for laboratory testing and to provide an understanding of subsurface conditions in the area of the landslide and adjacent areas proposed for construction. Borings B-1 through B-4 were advanced with 8-inch diameter hollow stem auger to depths of approximately 38, 60, 72 and 64 feet, respectively. Borings B-1, B-3 and B-4 were advanced beyond the auger depth using an NX core to depths of approximately 90½, 83 and 70 feet, respectively. Boring B-2 was augured to a depth of approximately 60 feet at which depth practical auger refusal was met in bedrock. The borings were logged and soil samples obtained by an engineer from AGEC. Logs of the subsurface conditions encountered in the borings are graphically shown on Figures 3 and 4 with Legend and Notes on Figure 5.

The subsurface conditions encountered at the site consist of up to approximately 1 foot of topsoil overlying clayey sand with some clayey gravel layers. Bedrock was encountered at depths of approximately 33, 60, 6 and 5 feet in Borings B-1, B-2, B-3 and B-4, respectively.

The topsoil consists of sandy lean clay with gravel. The topsoil is moist, dark brown in color and contains roots and organics.

The clayey sand contains a moderate amount of gravel and sandy clay layers. It is medium to very dense, slightly moist to very moist, yellowish to reddish brown in color with iron oxide staining.

The gravel contains cobbles and possibly some boulders. It is medium to very dense, slightly moist to very moist and yellowish, orangish brown to grayish brown in color.

The bedrock consists of quartzite which is highly fractured, hard to very hard, moist to very moist and reddish brown to yellowish brown to gray in color with iron oxide staining. The bedrock has clay filled fractures and shear zones.

LABORATORY TESTING

Triaxial shear tests were performed on samples of the soil and bedrock. The bedrock tested was taken from the clayey shear zone. Results of the triaxial shear tests are presented on Figures 13 and 14. Effective strengths consisting of a cohesion of 475 pounds per square foot and a friction angle of 34 degrees were measured for the soil. A cohesion of zero and friction angle of 47 degrees was measured for the portion of the bedrock obtained from a shear zone.

STABILITY ANALYSIS

The strengths of the weathered bedrock and overburden materials were estimated from the triaxial shear test and using the pre-slide profile assuming that there is water in the slope. Rotational and block failure analyses were conducted on the profile aided by a computer using the Bishop and Simplified Janbu Methods of analysis. Printouts of stability runs are included in the Appendix. Preslide material strengths are estimated to include an internal friction angle of 38 degrees and a cohesion of 400 psf for failures along the fracture zones. The remaining portion of the bedrock is assumed to have a friction angle of 47 degrees with no cohesion and not fully saturated. The soil is assumed to have a cohesion of 475 psf with a friction angle of 34 degrees.

Stability of adjoining steep slopes were evaluated using the added information from Borings B-3 and B-4 and assuming similar material strengths.

Since the slide appears to have occurred in the upper soil and along fracture planes in the weathered bedrock, we conclude that the depth of future sliding would be limited by the orientation of fractures in the bedrock and the thickness of overburden soil. The thickness of overburden soil is estimated to have been approximately 65 feet in the central portion of the slide and approximately 33 feet in the upper portion of the slide in the area of Boring B-1.

If the landslide were recontoured and flattened, we have assumed a friction angle of 37 degrees and no cohesion for replacement fill. An infinite slope analysis was used in evaluating safety factors for the fill slope under static and pseudostatic conditions.

RECOMMENDATIONS

A. <u>Building Setback</u>

Results of the stability analysis indicate that the buildings should be set back at least the distance indicated on Figure 2. The setback distance for the area of the slide assumes that the soil could continue to ravel back to a similar slope configuration as exists on the landslide with an added 50 foot buffer zone.

Based on the additional drilling, the overburden thickness is significantly less for the areas to the southwest of the landslide than what was encountered at the upper end of the landslide. Bedrock is exposed along the road which has been cut along the slope and bedrock is exposed along the ridge which extends down the slope just north of Section D to D′. Less clay was encountered in fractures in the bedrock encountered in Borings B-3 and B-4 than what was encountered in Borings B-1 and B-2. We anticipate that this bedrock is significantly more permeable and less susceptible to buildup of pore pressure. Strength parameters needed to provide a stable slope for the bedrock are lower than the strengths that are expected for this type of material. The setback line indicated on Figure 2 provides adequate safety factors against slope failure for buildings constructed south of this setback line.

B. Slope Modification

Modifications to the slope north of the setback line should be considered on an individual basis. Generally, excavation at the toe of the slope or placement of fill at the top of the slope would reduce the overall stability of the slope and may require a modification to the setback line. Storm runoff and drainage from the proposed development should not discharge into the soil or bedrock above this slope, but should be collected and directed to areas either south of Profile Line D to D′ or areas downslope of the landslide and areas downslope of steeply sloping portions of the site.

C. Landslide Recontouring

Recontouring the landslide using granular backfill as indicated below results in the following calculated safety factors for the various slope configurations.

	Safety Factor	
Slope	Static	Seismic
1.5H:1V	1.1	1.0
1.75H:1V	1.3	1.1
2H:1V	1.5	1.3

Slopes below the proposed ski trail should be constructed no steeper than 1.5H:1V which would provide a safety factor of at least 1 under seismic conditions. Slopes of 1.75H:1V or flatter may be used below roads and 2H:1V or flatter may be used below buildings.

Filling of the landslide should consist of removal of the vegetation in areas to receive fill. Fill placed on hillsides with slopes greater than 5 horizontal to 1 vertical should be keyed into the hillside. A key should be cut near horizontal in existing slopes. A key should be provided for at least every 2 feet of vertical rise. The filling operation should be performed by placing material at the toe of the slope and bringing the area up to the desired grade.

The fill should be placed in horizontal lifts and compacted to at least 90 percent of the maximum dry density as determined by ASTM D-1557.

Fill should consist of granular material with less than 35 percent passing the No. 200 sieve and a maximum size generally less than the lift thickness. If large rock is used in the fill, large particles should be isolated so they do not form large voids between large particles.

The top 2 feet of the fill over the entire slope should consist of low permeable soil, preferably gravel with at least 25 percent clay. This soil layer will reduce water infiltration into the fill and allow revegetation of slopes.

D. Erosion Protection

The final slope should be protected from erosion by revegetation or other methods.

E. Other Options

Other methods for allowing construction of buildings closer to the landslide would consist of installation of a deep seated retaining system such as closely spaced, large diameter reinforced concrete piers. Such a system would be relatively expensive. Additional recommendations could be provided if such a system is considered feasible.

LIMITATIONS

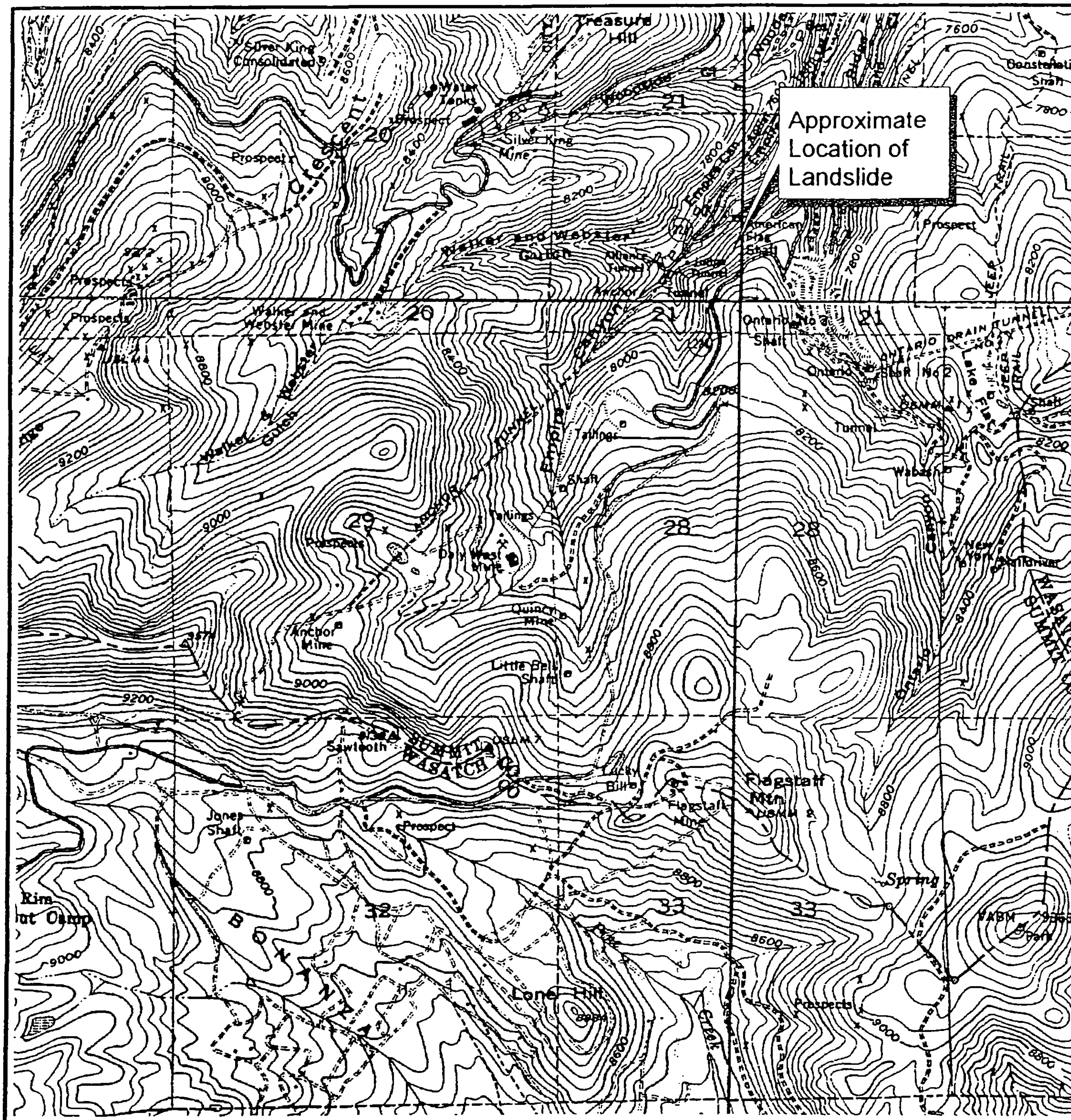
This report has been prepared in accordance with generally accepted soil engineering practices in the area for the use of the client. The conclusions and recommendations included within the report are based on the information obtained from the borings, aerial photographs and reconnaissance of the site. Variations in subsurface conditions may not become evident until additional exploration or excavation is conducted. If subsurface soil conditions are found to be different from what is described in this report, we should be notified to reevaluate the recommendations given.

If you have any questions, or if we can be of further service, please call.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

Douglas R. Hawkes, P.E., P.G.

Reviewed by JEN, P.E.
DRH/cs
enclosures
cc: Mark Froelich



Sections 21 28 & 29, T2S, R4E, SLB&M

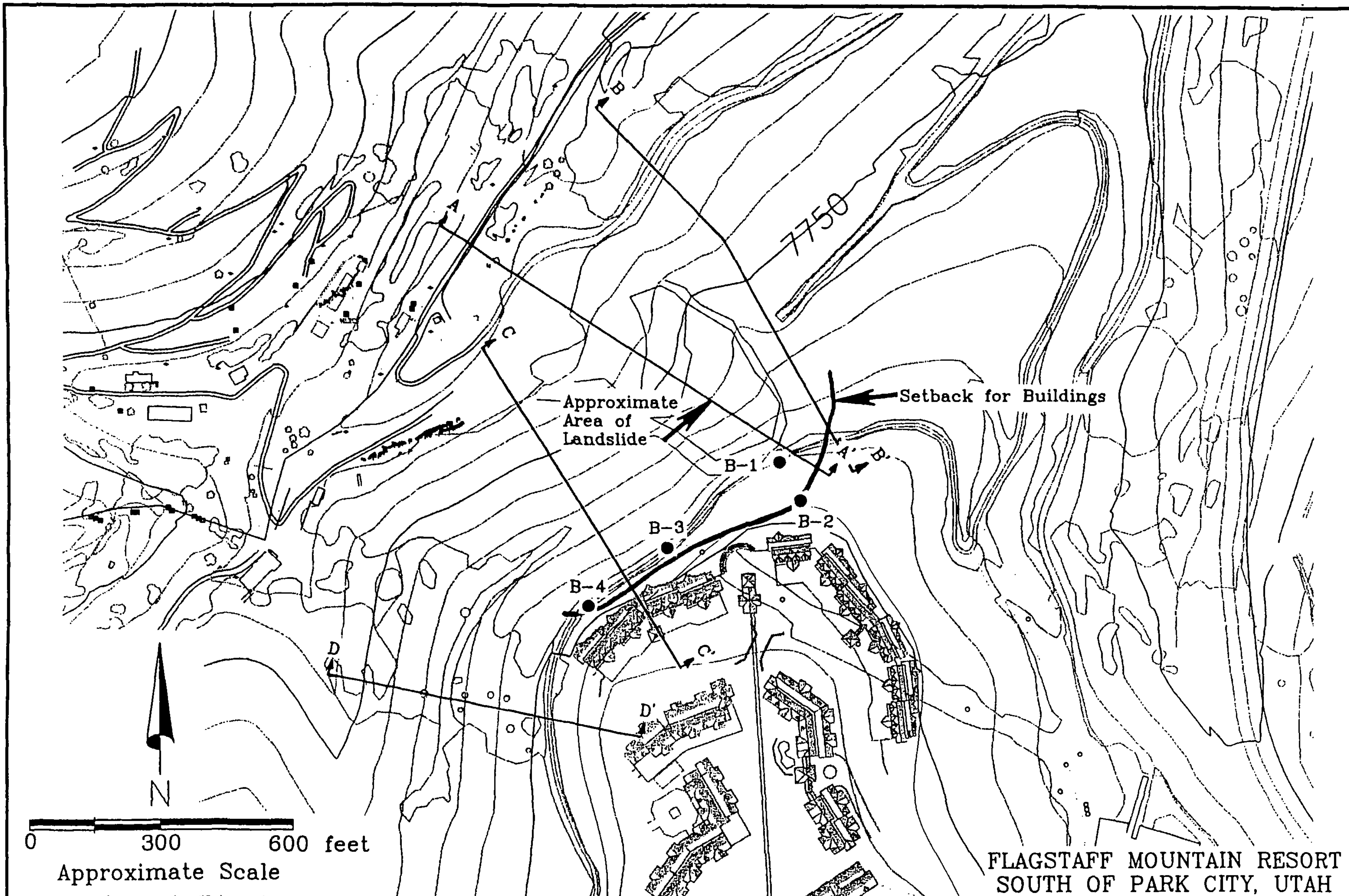
From USGS Brighton, Heber City, Park City East and Park City West Quadrangles and GDT Dynamap (January 2000)

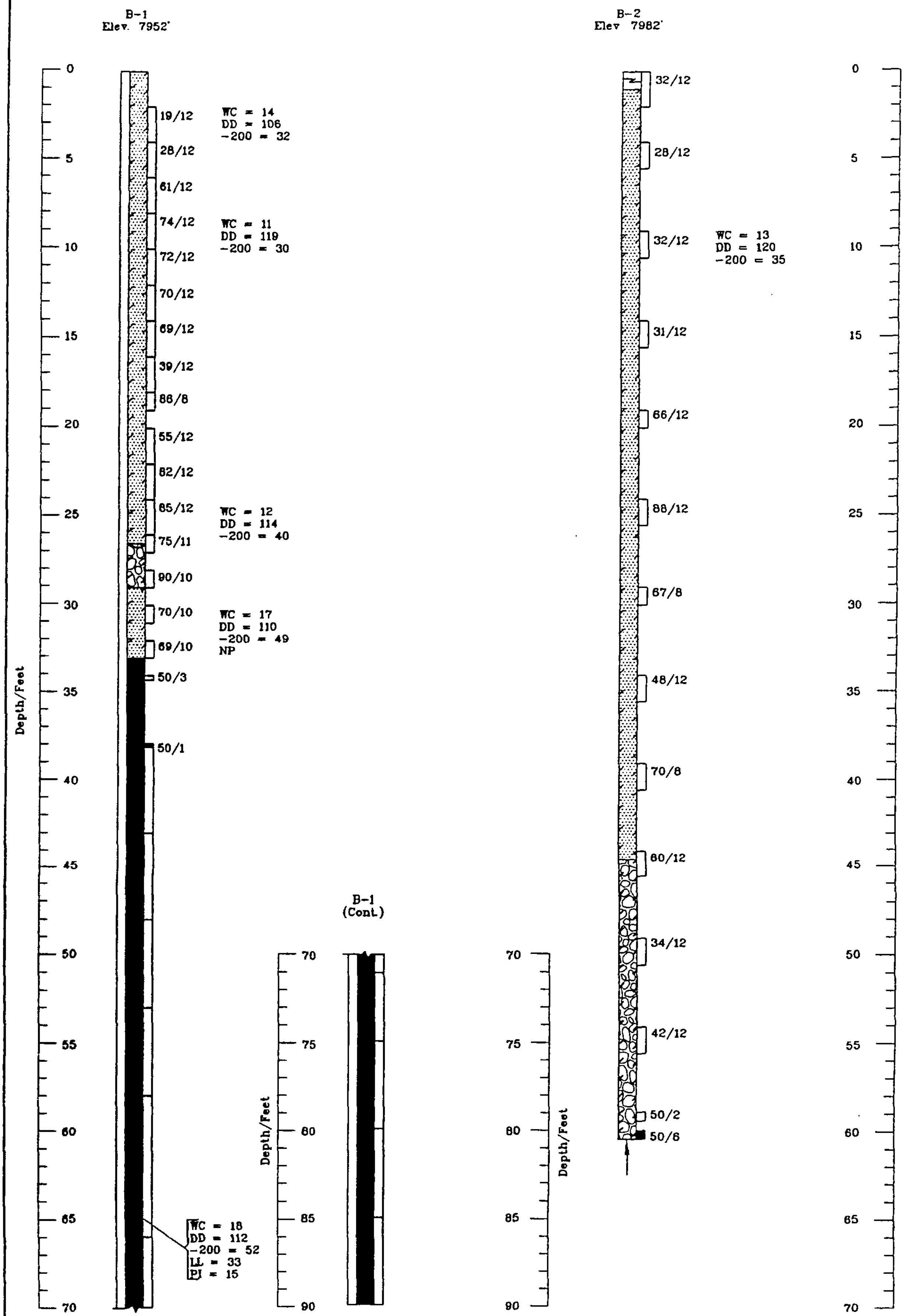
N

Approximate Scale
1 inch = 2,000 feet

Flagstaff Mountain Resort
South of Park City, Utah

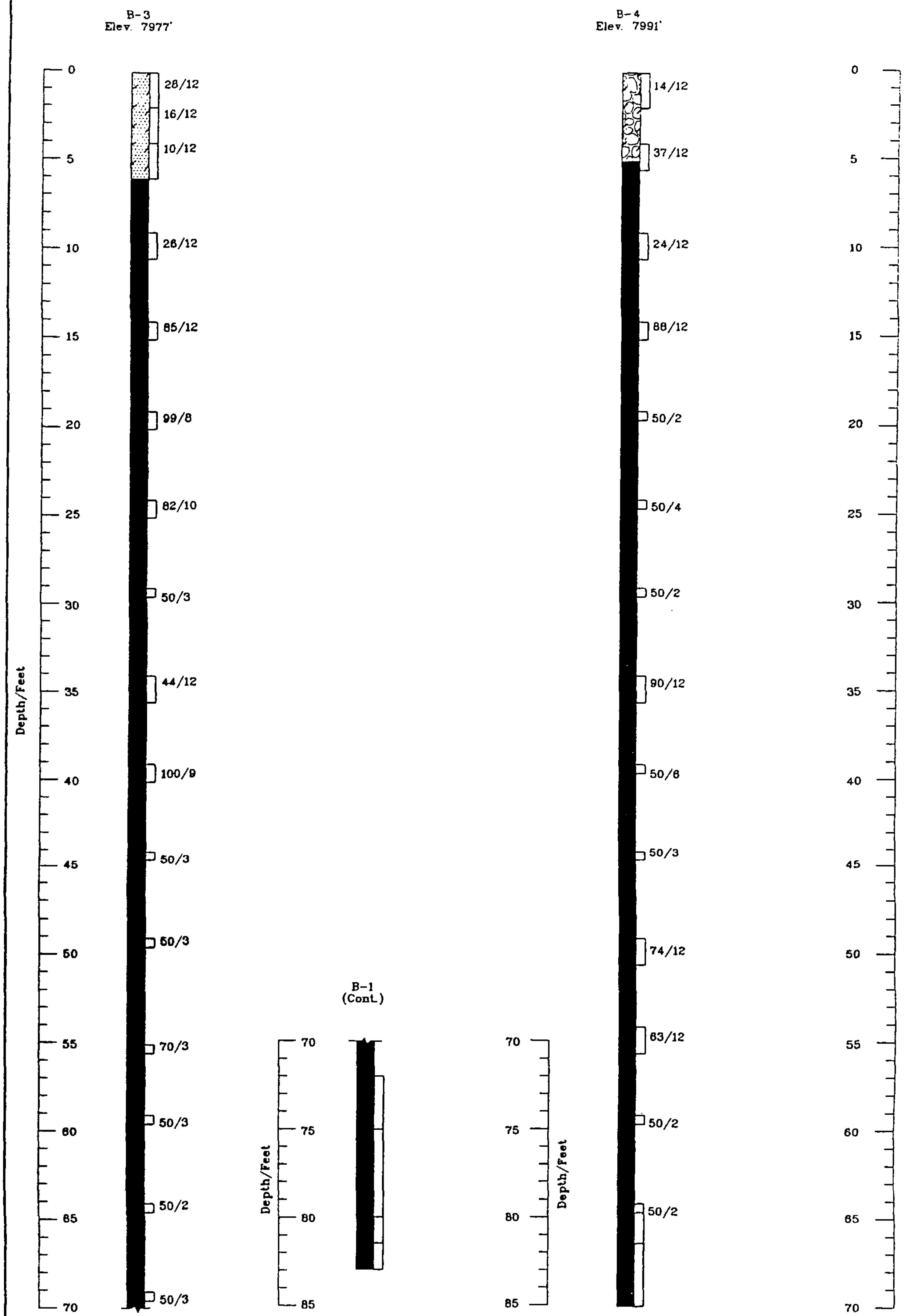
1000208D	AGEC	Approximate Site Location	Figure 1


B
A
C
7750
Setback for Buildings
Approximate
Area of
Landslide
B-1
A'
B'
B-2
B-3
B-4
C'
D
D'
N
0
300
600 feet
Approximate Scale
FLAGSTAFF MOUNTAIN RESORT
SOUTH OF PARK CITY, UTAH



Approximate Vertical Scale 1" = 8'

See Figure 5 for Legend and Notes



Approximate Vertical Scale 1" = 8'

See Figure 5 for Legend and Notes

1000208D	AGES	Logs of Exploratory Borings	Figure 4

LEGEND:

Topsoil; clayey to silty sand with gravel to sandy lean clay with gravel, cobbles and occasional boulders up to approximately 2 feet in size, slightly moist to moist, dark brown, roots, organics.

Clayey Sand with Gravel (SC); sandy clay layers, cobbles up to approximately 10 inches in size, medium dense to very dense, slightly to very moist, yellow to reddish brown, iron oxide staining.

Clayey Gravel with Sand (GC); small to moderate amount of clay, sandy clay and clayey sand layers, cobbles, boulders up to approximately 6 feet in size, high plastic clay zones, medium to very dense, slightly moist to very moist, reddish brown to orange brown to gray to yellowish brown, iron oxide staining.

Quartzite Bedrock; highly fractured, clay filled fractures and shear zones, hard to very hard, moist to very moist, reddish brown to yellowish brown to gray, iron oxide staining.

10/12 California Drive sample taken. The symbol 10/12 indicates that 10 blows from a 140 pound hammer falling 30 inches were required to drive the sampler 12 inches. An automatic hammer was used for Boring B-2.

10/12 Standard Penetration Test taken. The symbol 10/12 indicates that 10 blows from a 140 pound hammer falling 30 inches were required to drive the sampler 12 inches. An automatic hammer was used for Boring B-2.

Indicates portion of boring drilled with NX coring equipment.

Indicates slotted 1¼ inch PVC pipe installed in the boring to the depth shown.

Indicates practical auger refusal.

NOTES:

1. Boring B-1 was drilled on June 28, 2000 with 8-inch diameter hollowstem auger to a depth of approximately 38 feet. It was extended June 29 and 30, 2000 from 38 to 90½ feet using NX core. Boring B-2 was drilled July 5, 6, and 7, 2000 with 8-inch diameter hollowstem auger. Boring B-3 was drilled on October 10 and 11, 2000 with 8 inch diameter auger to a depth of 72 feet. It was extended October 11 and 12, 2000 from 72 to 83 feet using NX core. Boring B-4 was drilled on October 23 and 24, 2000 with 8 inch diameter auger to a depth of 64 feet. It was extended October 24, 2000 from 64 to 70 feet using NX core.

2. Locations of Borings B-1 and B-2 were surveyed by Alliance Engineering. Borings B-3 And B-4 were located based on features shown on the site plan.

3. Elevations of Borings B-1 and B-2 were surveyed by Alliance Engineering. Elevations for Borings B-3 and B-4 were determined by interpolating between contours shown on the site plan provided.

4. The boring locations and elevations should be considered accurate only to the degree implied by the method used.

5. The lines between the materials shown on the boring logs represent the approximate boundaries between material types and the transitions may be gradual.

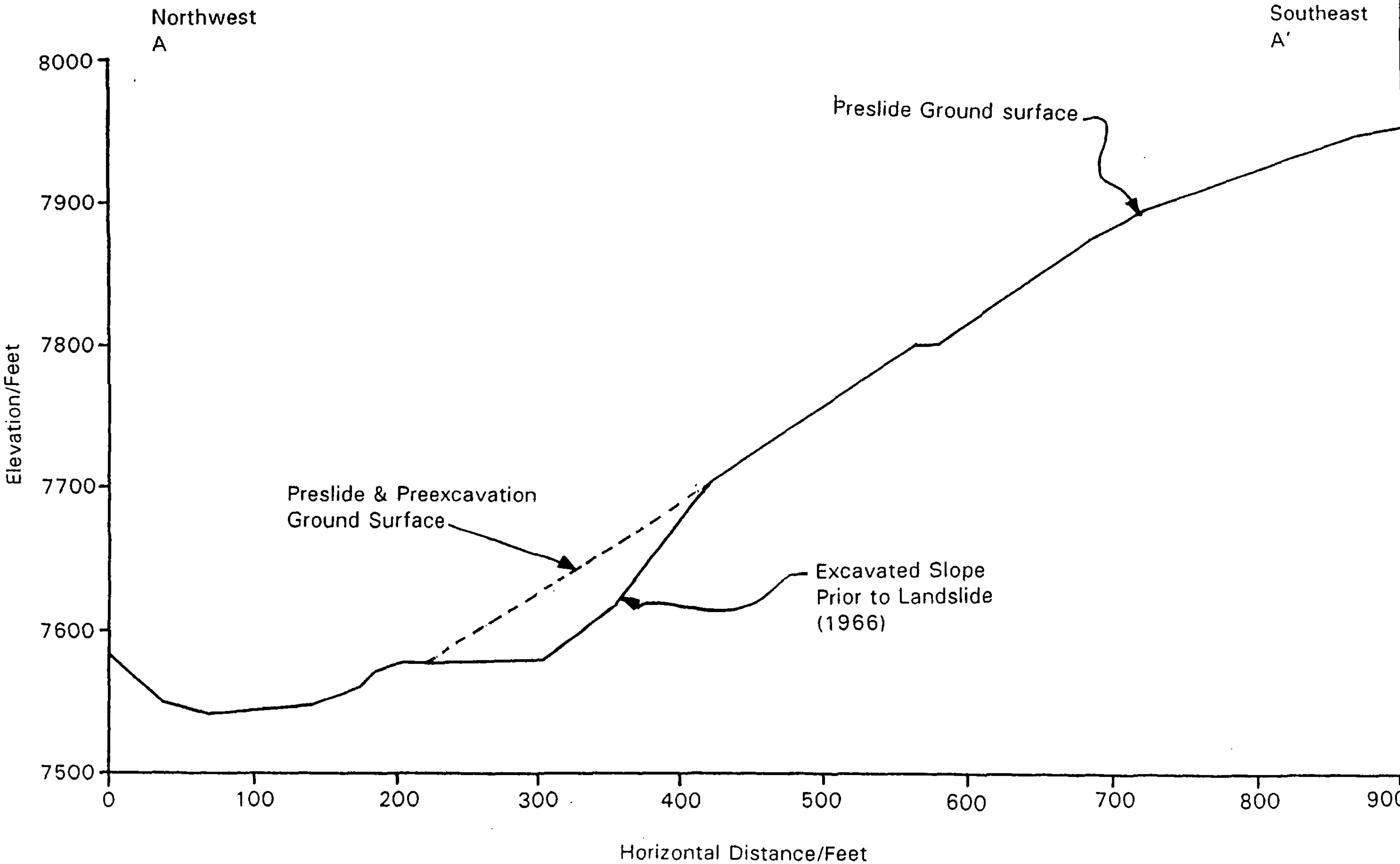
6. No free water was encountered in borings at the time of drilling.

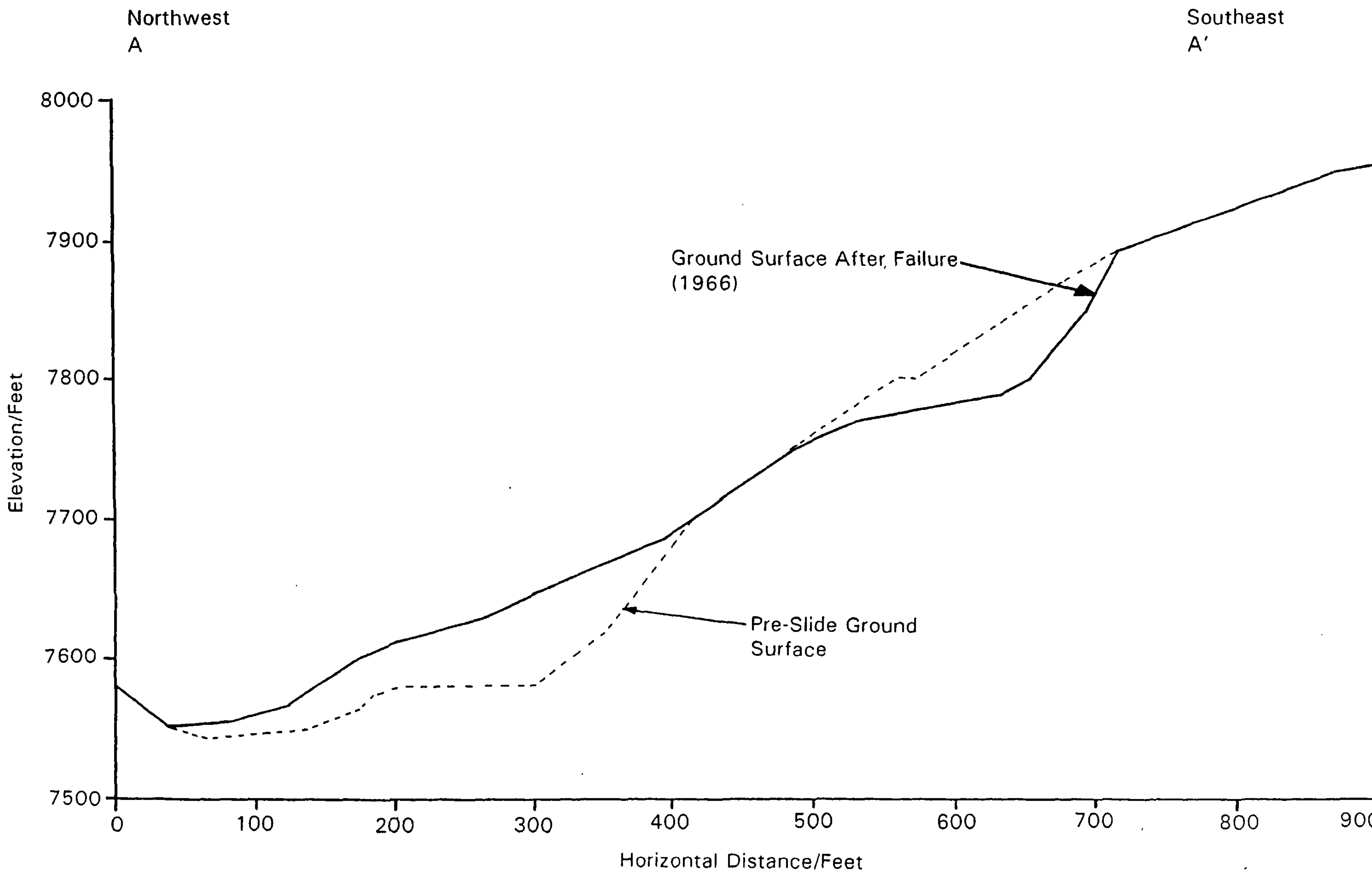
7. WC = Water Content (%);
   DD = Dry Density (pcf);
   -200 = Percent Passing No. 200 Sieve;
   LL = Liquid Limit (%);
   PI = Plasticity Index (%);
   NP = Nonplastic.

1000208D

Preslide Profile through Landslide

Figure 6

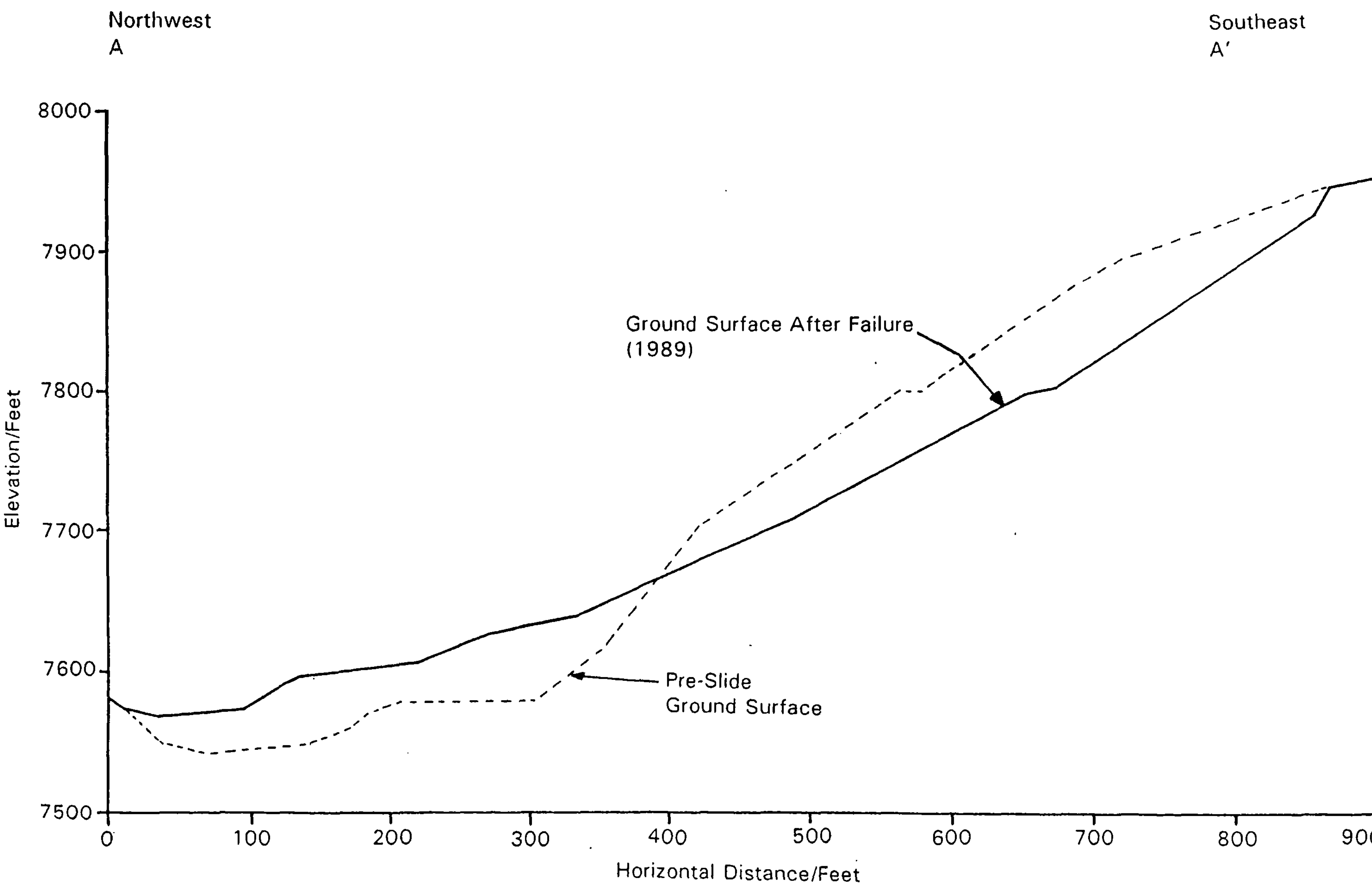




1000208D

Profile through Landslide after Failure (1966)

Figure 7



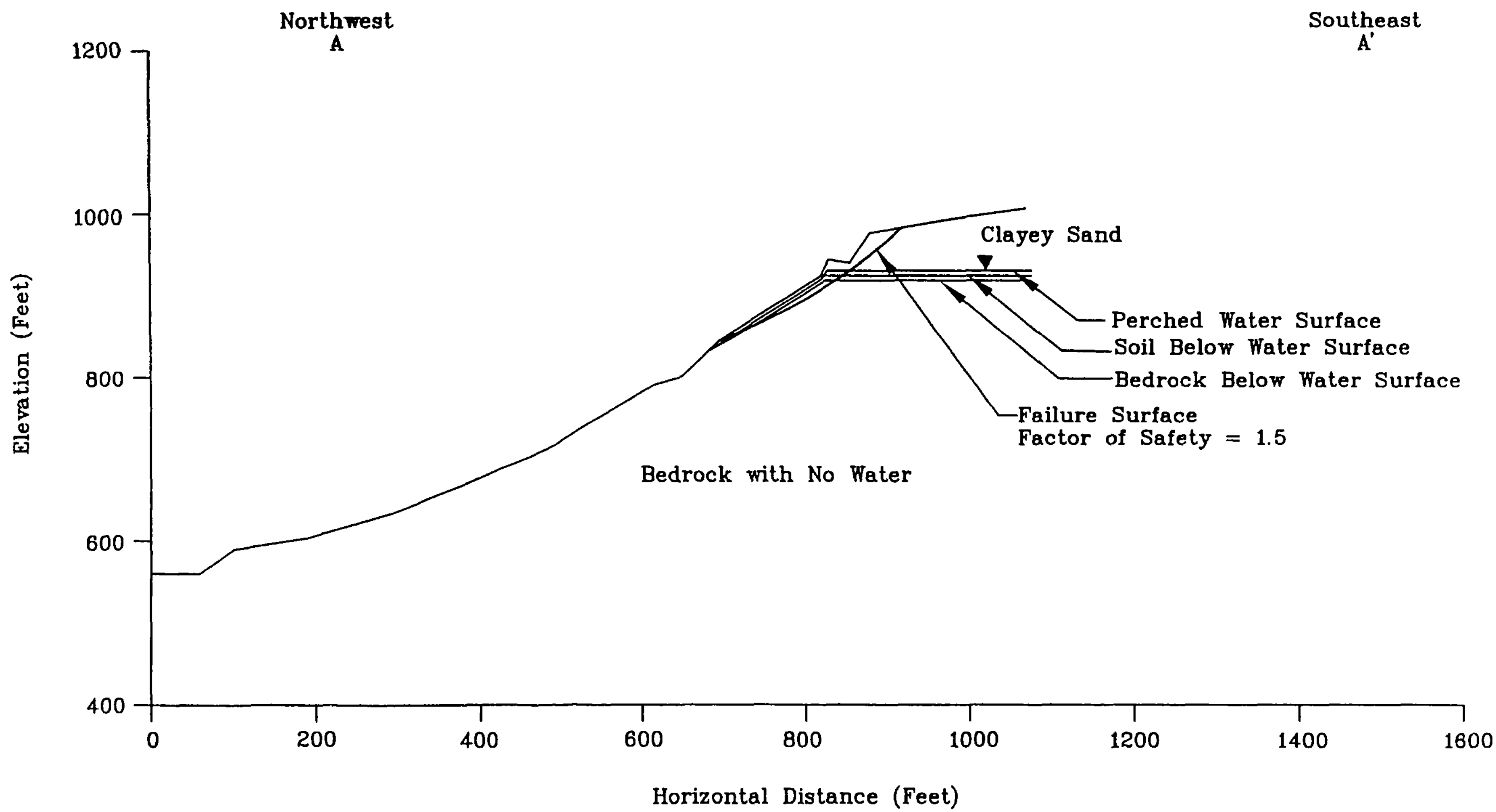
10000208D

AGEC

Profile Through Landslide After Failure (1989)

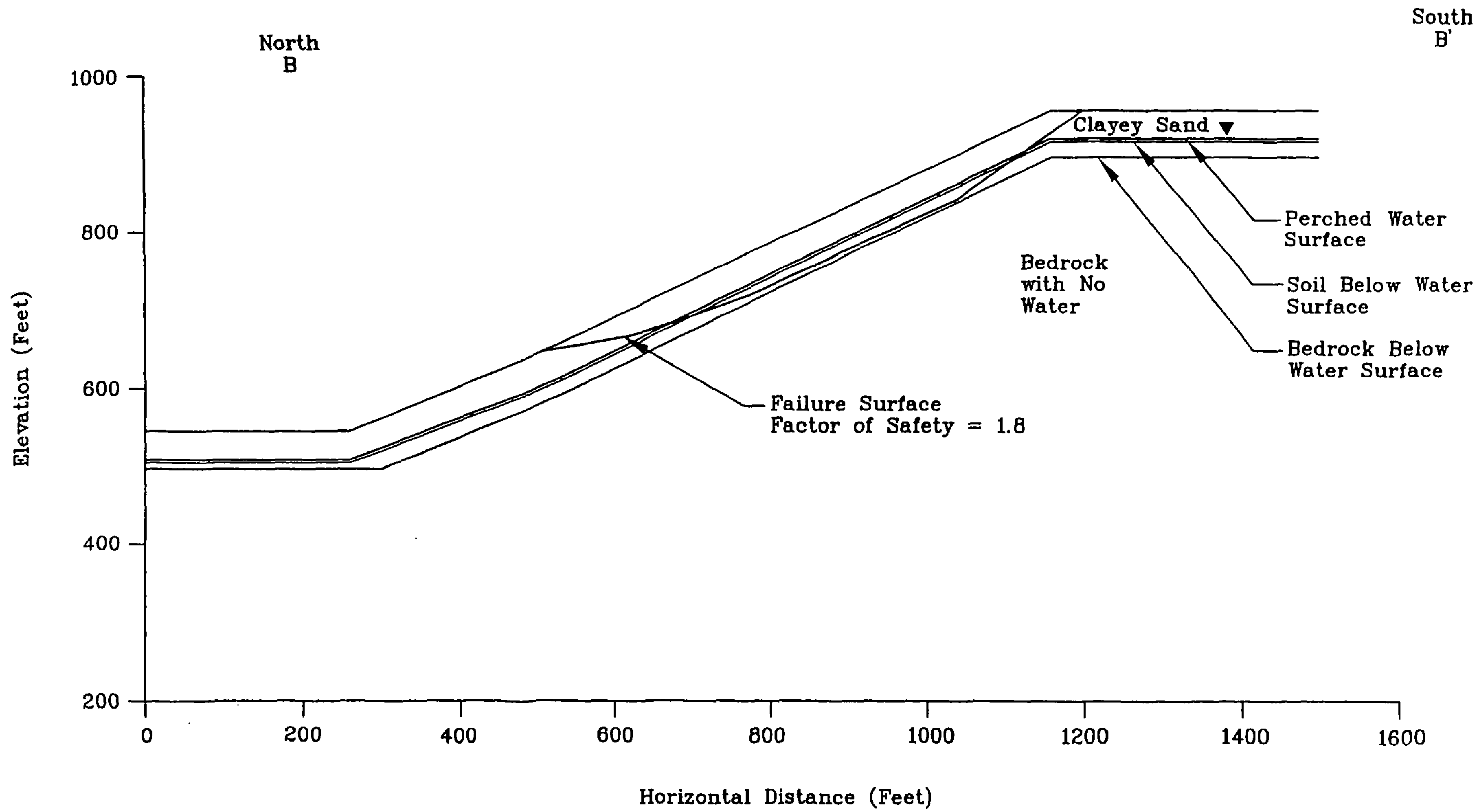
Figure 8

SOIL/BEDROCK PARAMETERS			
SOIL/BEDROCK	DENSITY (PCF)	FRICTION ANGLE (DEGREES)	COHESION (PSF)
Clayey Sand	130	34	475
Bedrock	130	47	0



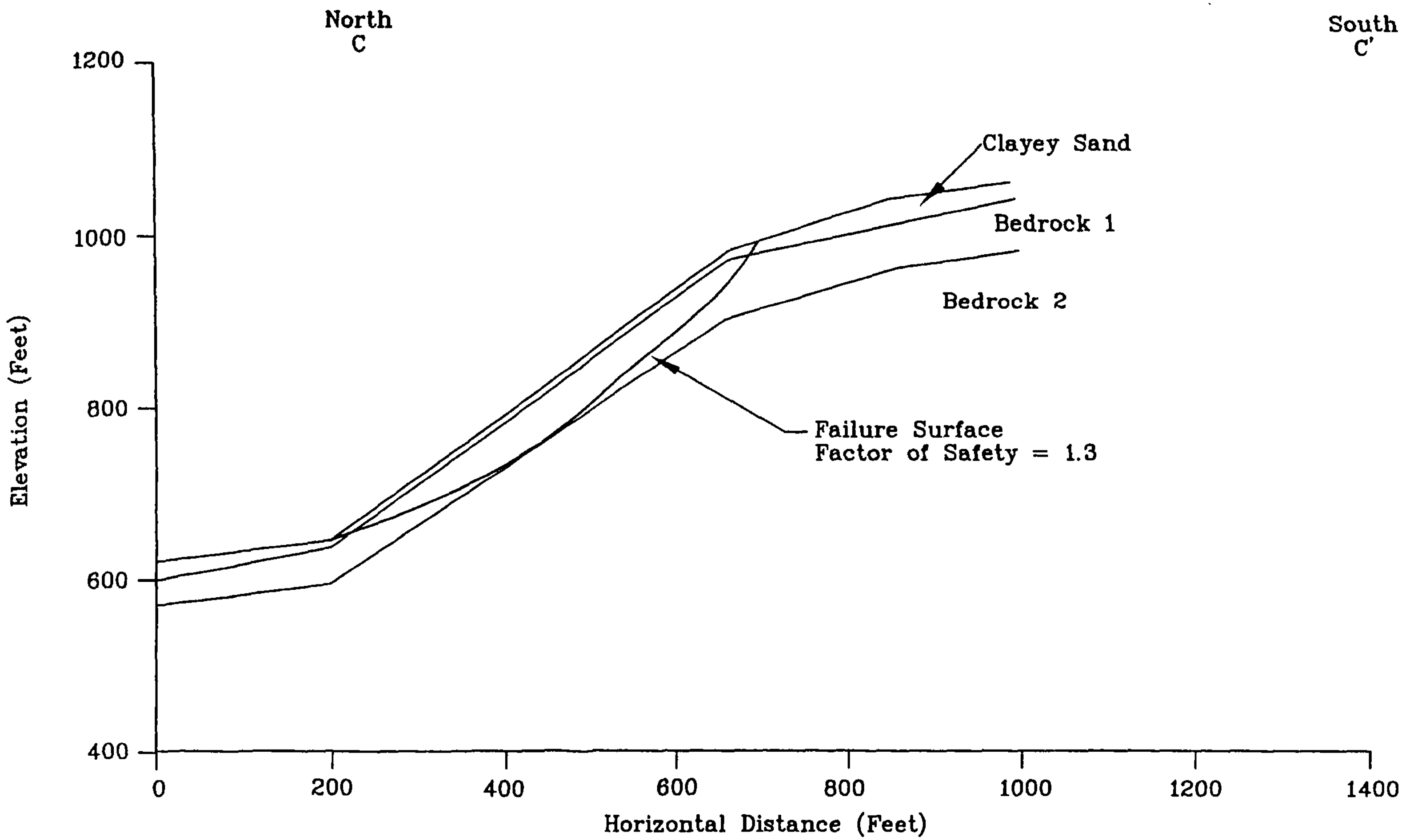
Empire Canyon Slope Stability Analysis Profile A–A'

SOIL/BEDROCK PARAMETERS			
SOIL/BEDROCK	DENSITY (PCF)	FRICTION ANGLE (DEGREES)	COHESION (PSF)
Clayey Sand	130	34	475
Bedrock	130	47	0



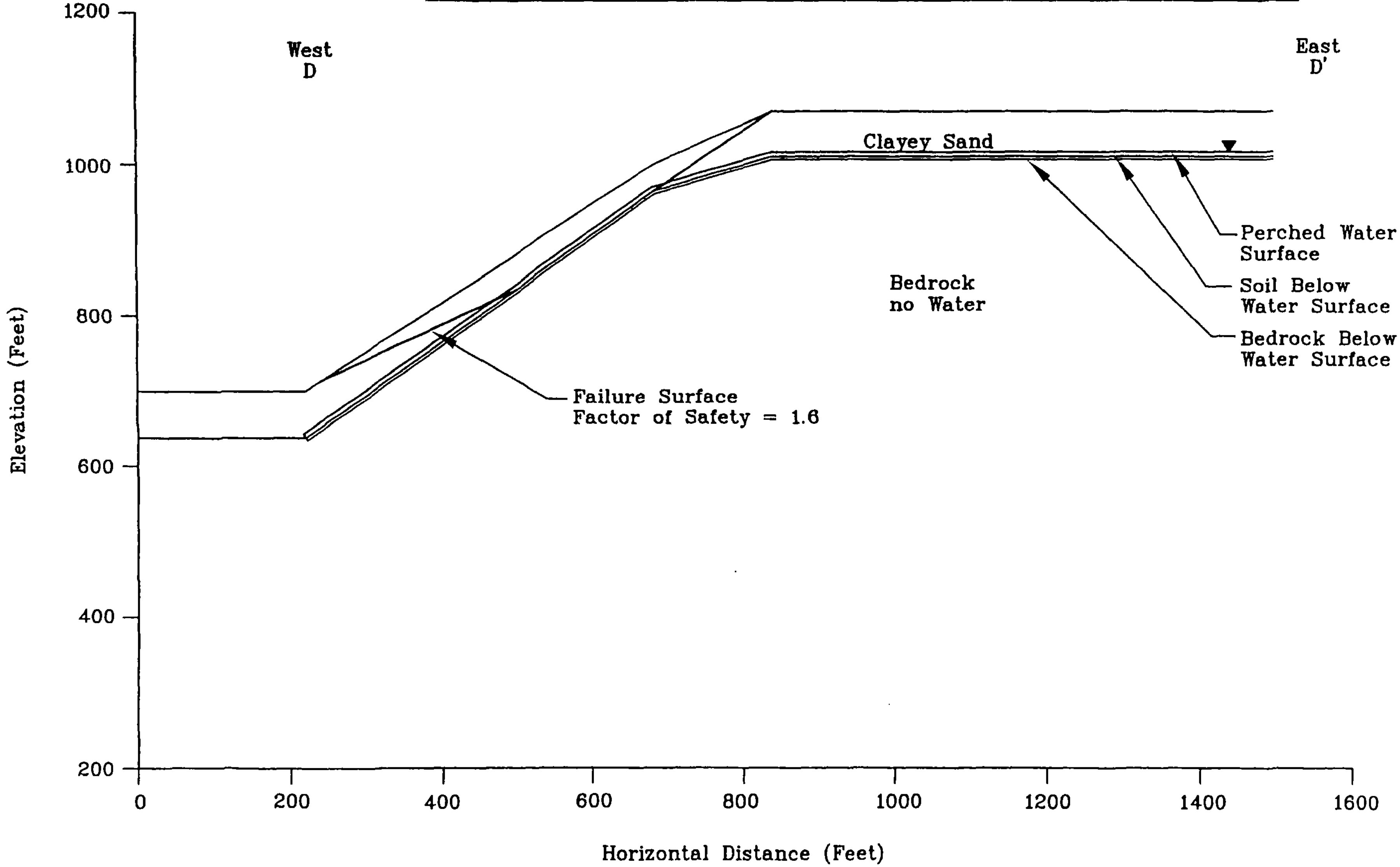
Empire Canyon Slope Stability Analysis Profile B–B'

SOIL/BEDROCK PARAMETERS			
SOIL/BEDROCK	DENSITY (PCF)	FRICTION ANGLE (DEGREES)	COHESION (PSF)
Clayey Sand	130	34	475
Bedrock 1	130	38	400
Bedrock 2	130	38	400



Empire Canyon, Slope Stability Analysis, Profile C-C'

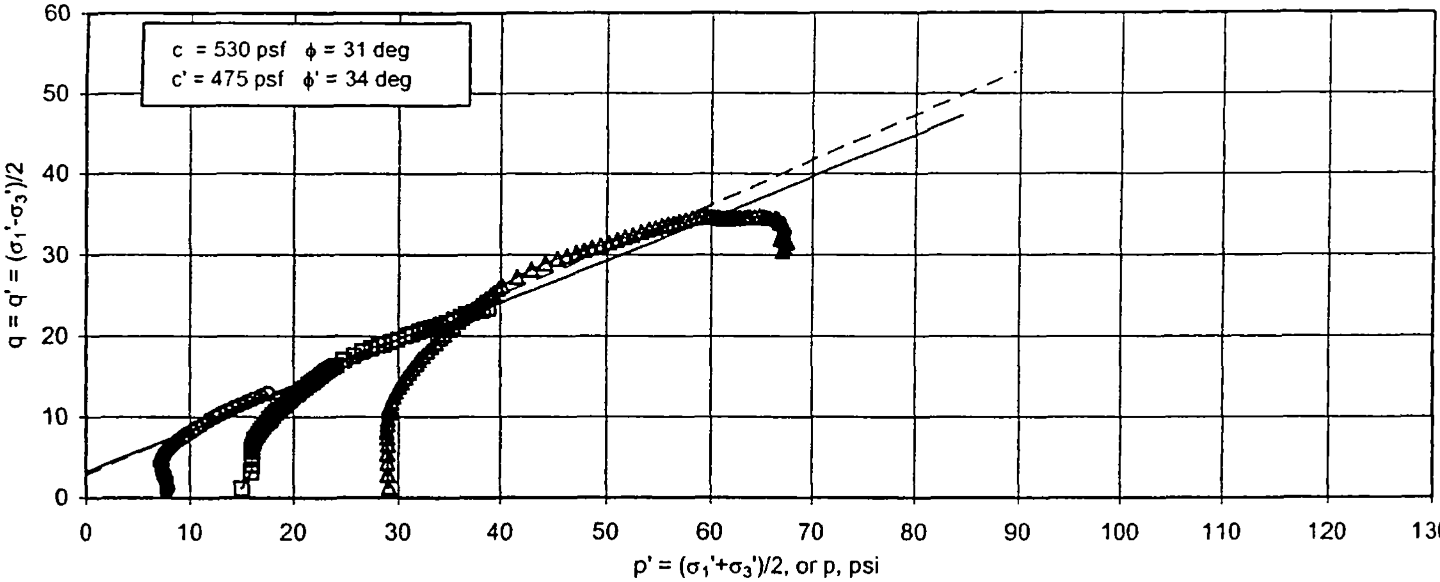
SOIL/BEDROCK PARAMETERS			
SOIL/BEDROCK	DENSITY (PCF)	FRICTION ANGLE (DEGREES)	COHESION (PSF)
Clayey Sand	130	34	475
Bedrock	130	47	0

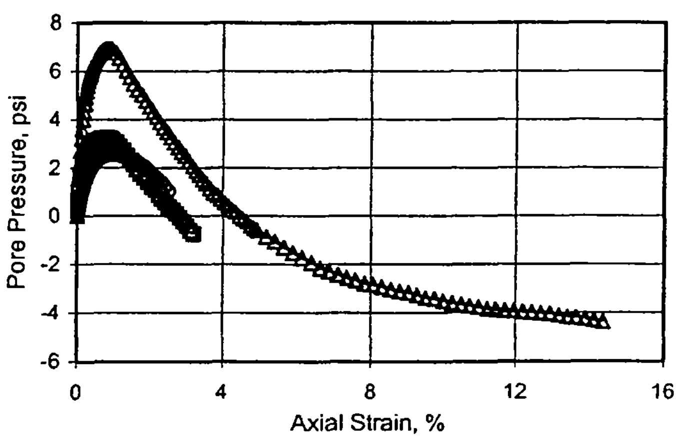


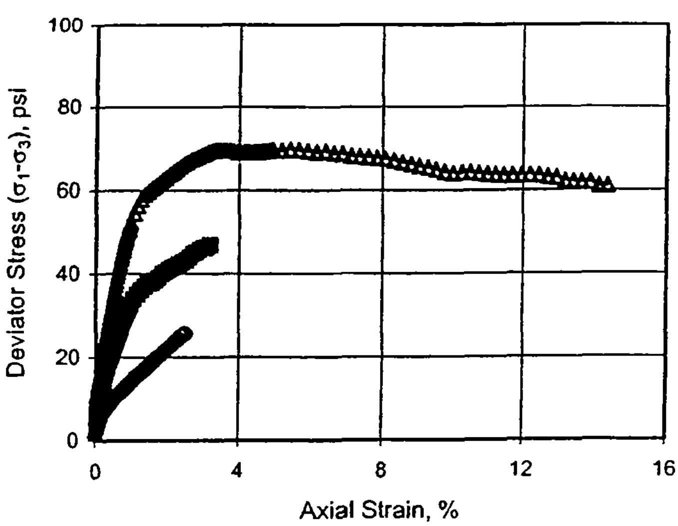
1000208D

Empire Canyon, Slope Stability Analysis, Profile D–D'

Applied Geotechnical Engineering Consultants, Inc.







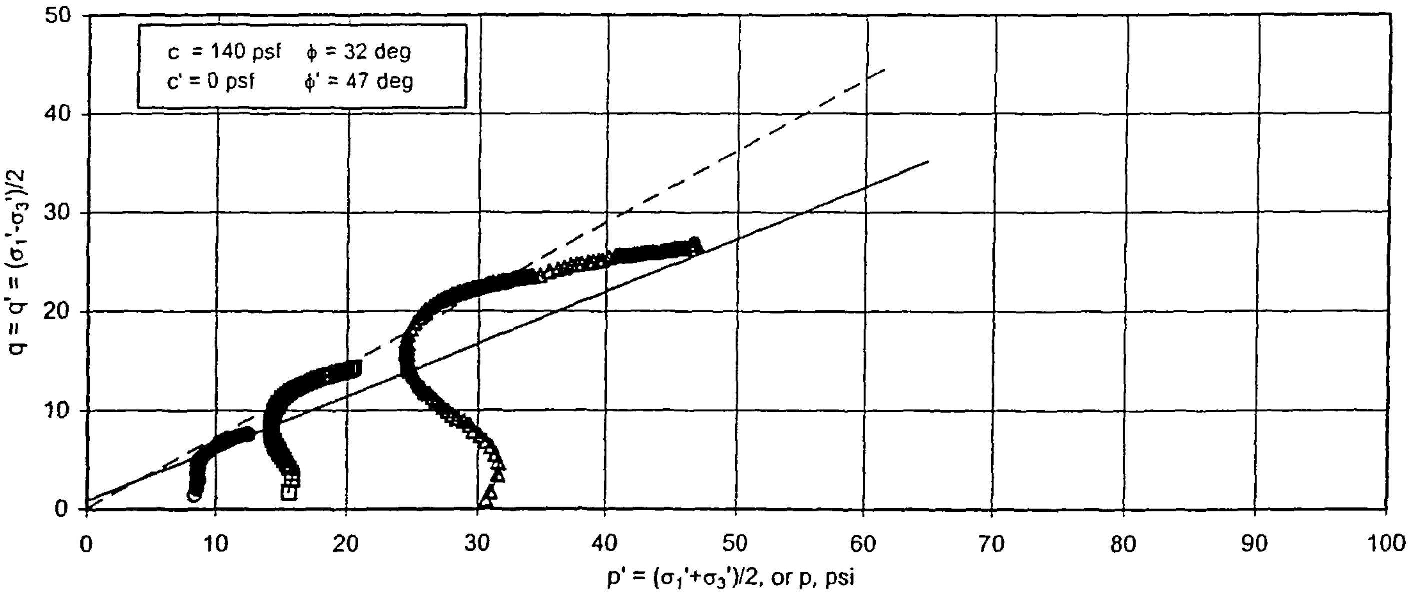
Test No. (Symbol)	○	□	△
Sample Type	Undisturbed		
Length, in.	3.61	3.54	3.46
Diameter, in.	1.91	1.93	1.96
Dry Density, pcf	114	N/A	N/A
Moisture Content, %	12	N/A	N/A
Consolidation Pressure, psi	6.9	13.9	27.8
"B" Parameter	96	96	96
Total Confining Stress (σ_3), psi	5.8	13.5	24.4
Total Axial Stress (σ_1), psi	31.5	56.8	90.6
Deviator Stress (σ_1-σ_3), psi	25.7	43.3	66.2
Effective Lateral Stress (σ_3'), psi	4.8	13.1	20.9
Effective Axial Stress (σ_1'), psi	30.5	56.4	87.1
Pore Pressure (μ), psi	1.0	0.4	3.5
Strain, %	2.5	2.5	2.5
Remarks	Multi-staged test (CU). Consolidated-undrained with pore pressure measurements. Sample saturated with back pressure saturation.		

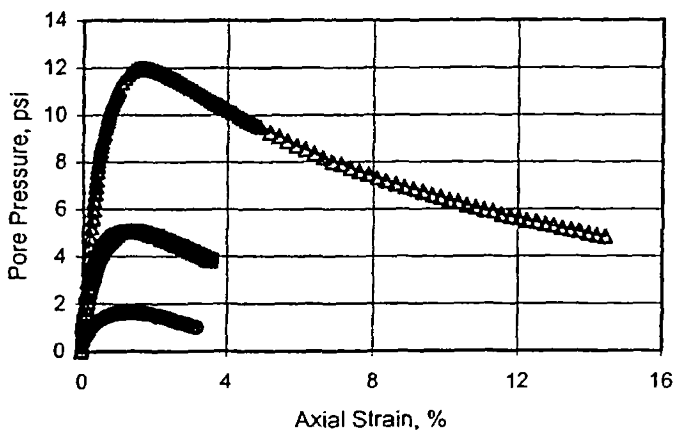
Sample Index Properties	
Natural Dry Density, pcf	114
Natural Moisture Content, %	12
Liquid Limit, %	N/A
Plasticity Index, %	N/A
Percent Gravel	N/A
Percent Sand	N/A
Percent Passing No. 200 Sieve	40

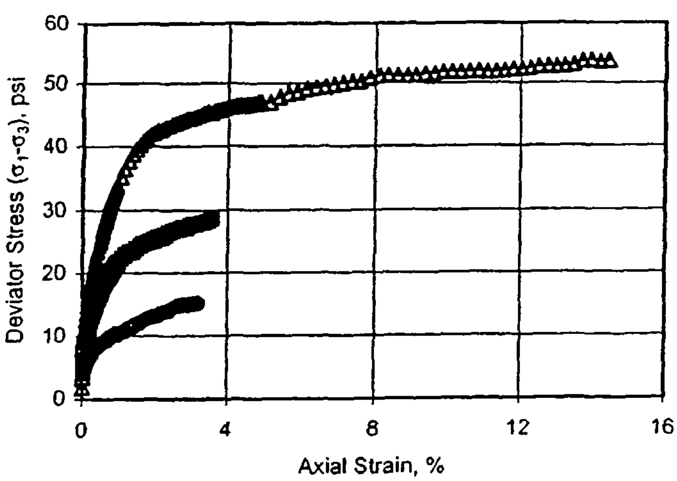
Sample Description Clayey Sand (SC) Sample Location B-1 @ 24'

Project No. 1000208D Figure 13

Applied Geotechnical Engineering Consultants, Inc.







Test No. (Symbol)	○	□	△
Sample Type	Remolded		
Length, in.	3.97	3.87	3.76
Diameter, in.	1.90	1.93	1.96
Dry Density, pcf	112	N/A	N/A
Moisture Content, %	18	N/A	N/A
Consolidation Pressure, psi	6.9	13.9	27.8
"B" Parameter	99	99	99
Total Confining Stress (σ_3), psi	5.8	9.7	18.6
Total Axial Stress (σ_1), psi	20.8	37.1	63.1
Deviator Stress (σ_1-σ_3), psi	15	27.5	44.5
Effective Lateral Stress (σ_3'), psi	4.7	5.4	7.5
Effective Axial Stress (σ_1'), psi	19.7	32.9	52
Pore Pressure (μ), psi	1.1	4.3	11.2
Strain, %	3.0	3.0	3.0
Remarks	Multi-staged test (CU). Consolidated-undrained with pore pressure measurements. Sample saturated with back pressure saturation.		

Sample Index Properties	
Natural Dry Density, pcf	N/A
Natural Moisture Content, %	18
Liquid Limit, %	33
Plasticity Index, %	15
Percent Gravel	N/A
Percent Sand	N/A
Percent Passing No. 200 Sieve	52

Sample Description Bedrock (Shear Zone) Sample Location B-1 @ 65'

Project No. 1000208D Figure 14

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NUMBER 1000208D

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION			ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	WATER SOLUBLE SULFATE (ppm)	SAMPLE CLASSIFICATION
BORING	DEPTH (FEET)			GRAVEL (%)	SAND (%)	SILT/ CLAY (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
B-1	2	14	106			32					Clayey Sand
	8	11	119			30					Clayey Sand
	24	12	114			40					Clayey Sand
	30	17	110			49		NP			Silty Sand
	65	18	112			52	33	15			Bedrock (Shear Zone)
B-2	9	13	120			35					Clayey Sand

APPENDIX

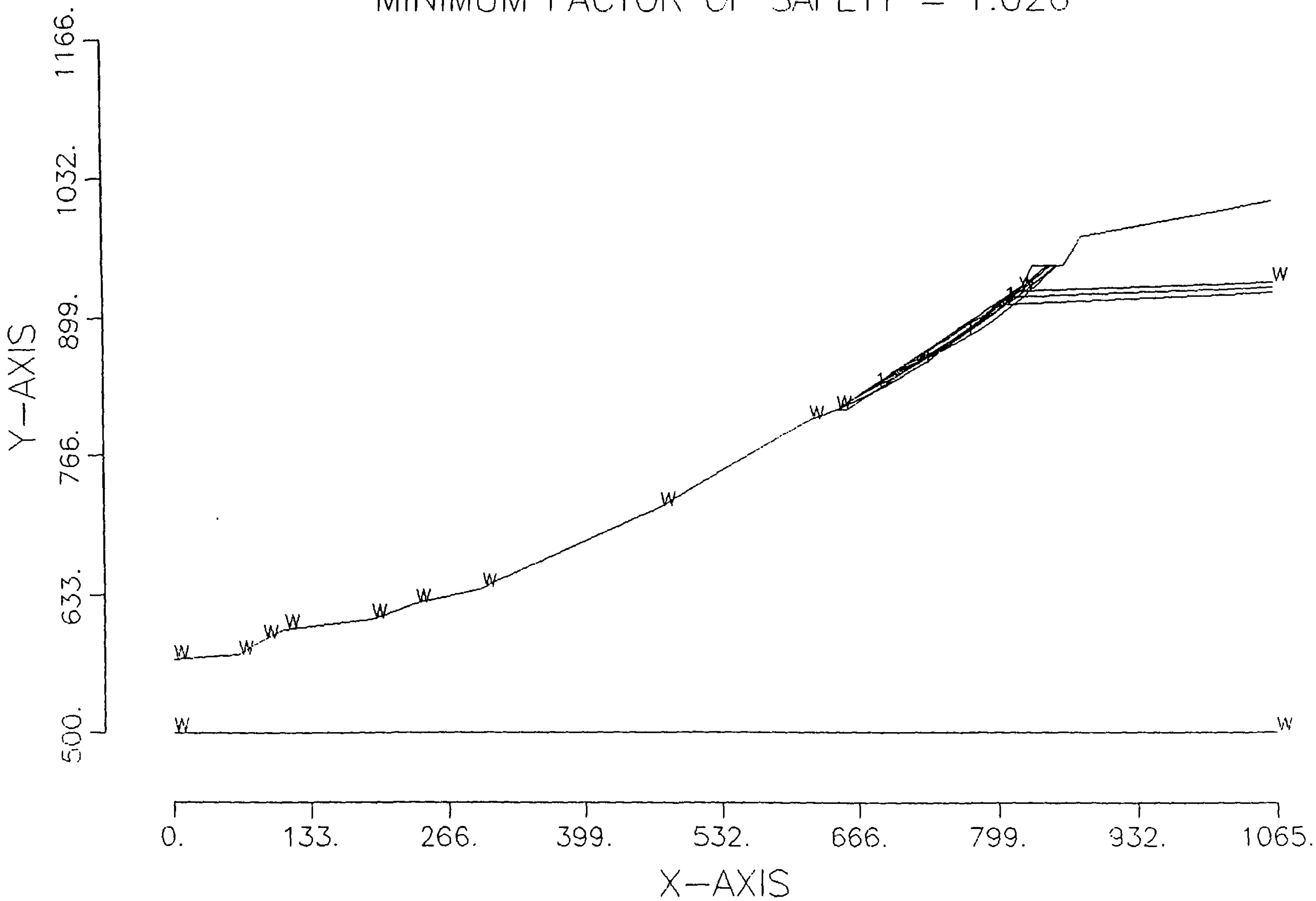
SLOPE STABILITY PRINTOUTS

Project No. 1000208D

AGE
Midvale UT s/n5206

EMPIRE CANYON A-A'

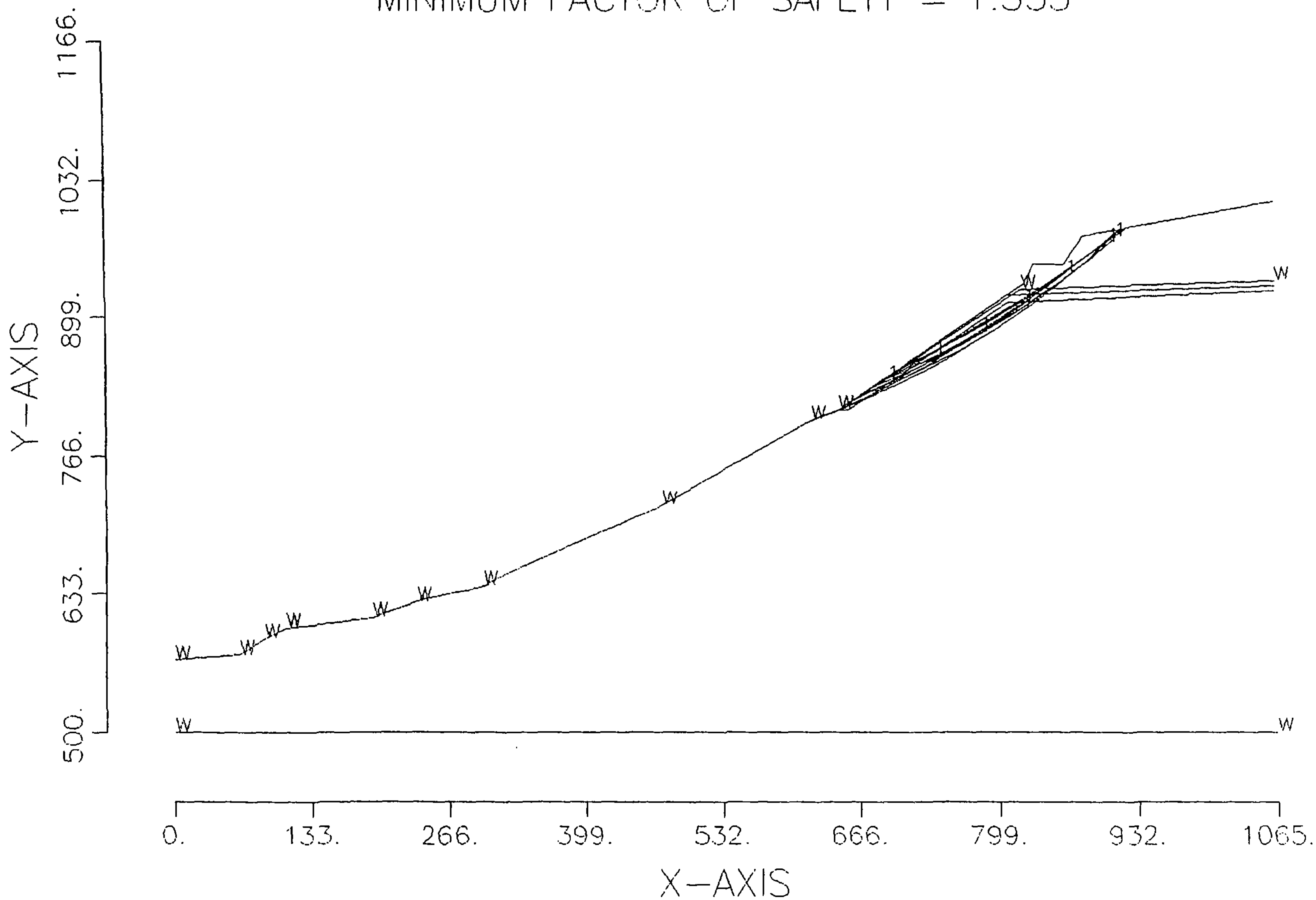
4000SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.026



AGE^
Midvale UT s/n5206

EMPIRE CANYON A - A'

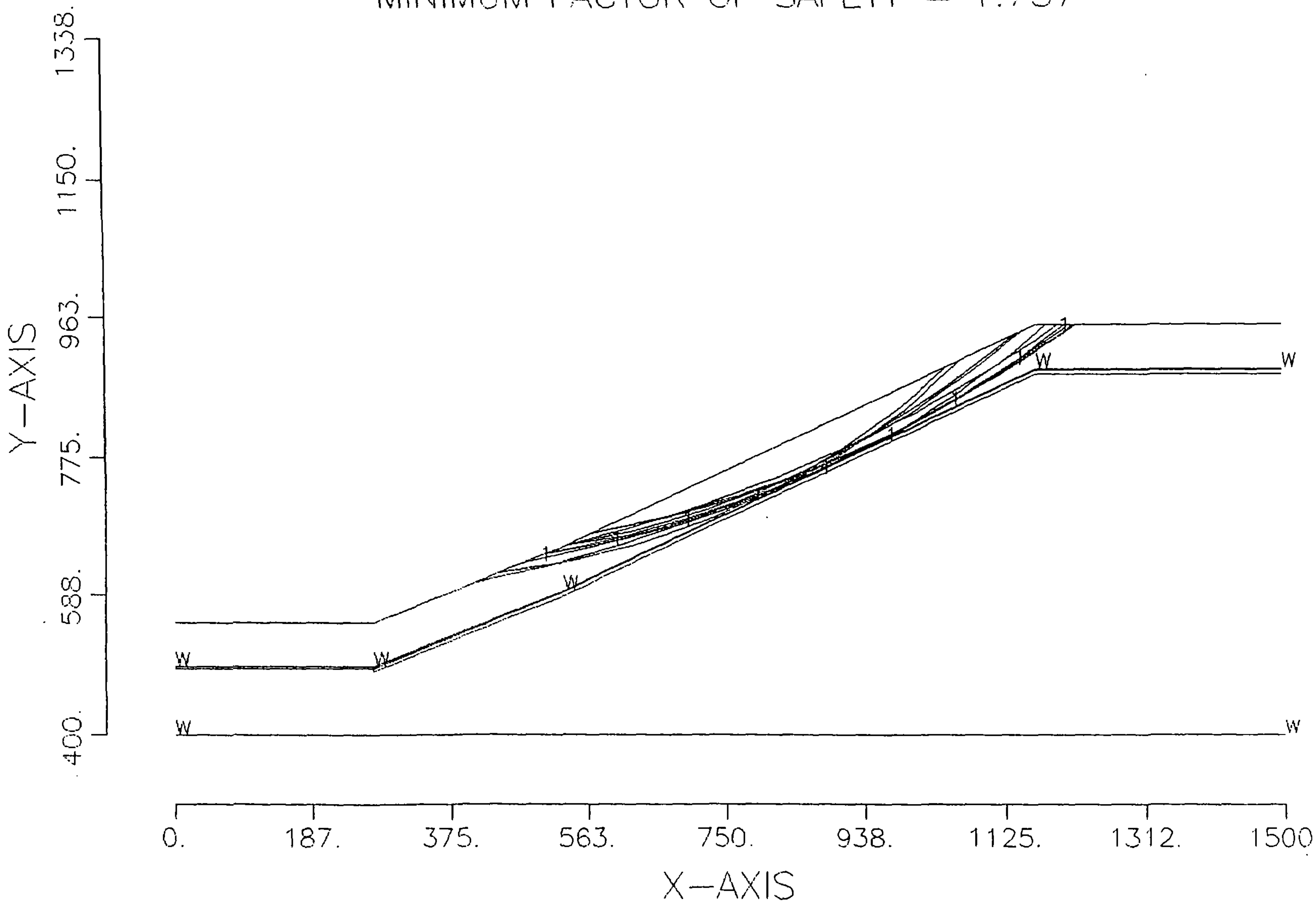
4000SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.533



AGE'
Midvale UT s/n5206

EMPIRE CANYON B-B'

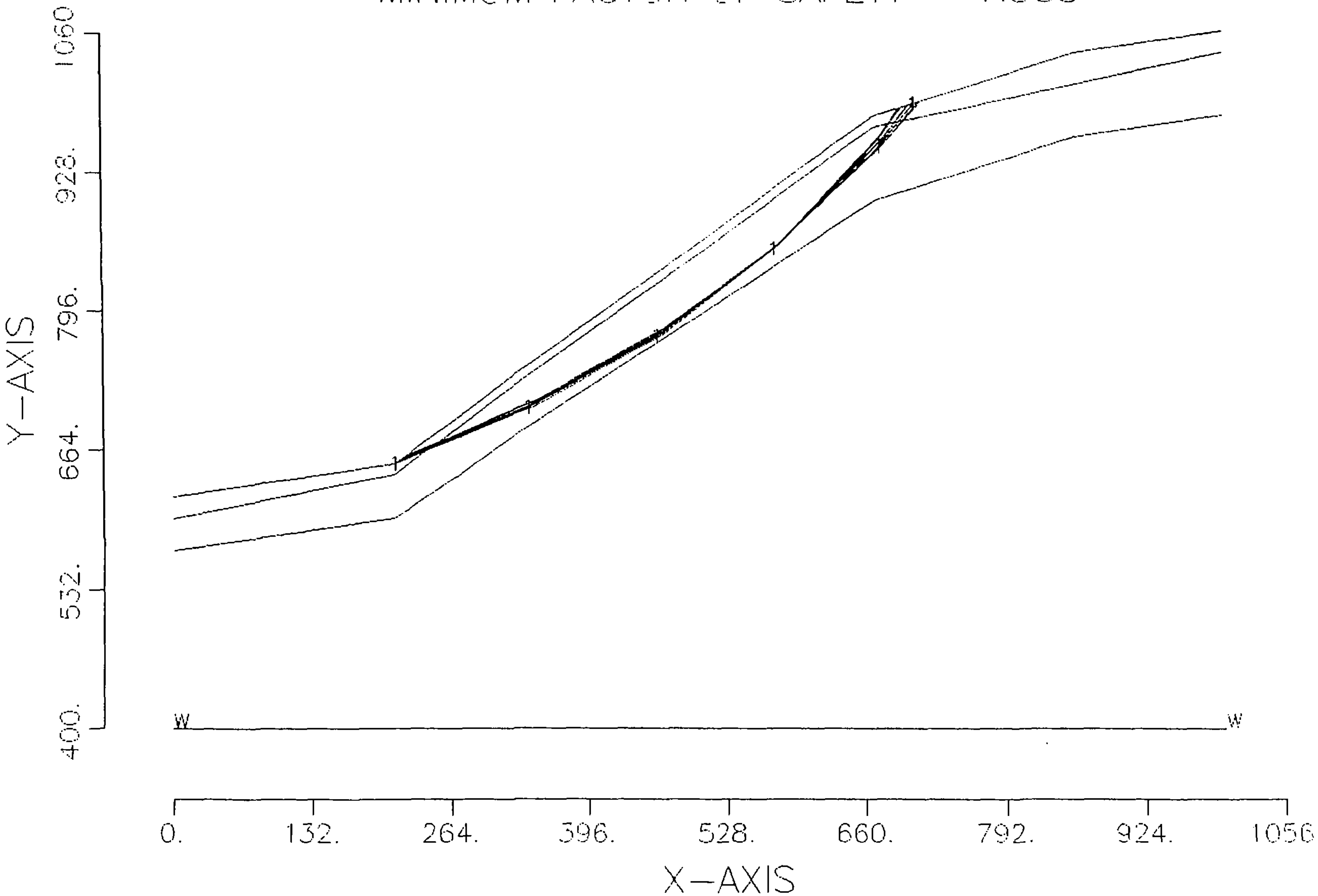
4000SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.757



AGE
Midvale UT s/n5206

EMPIRE CANYON C-C'

4000SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.335



AGE

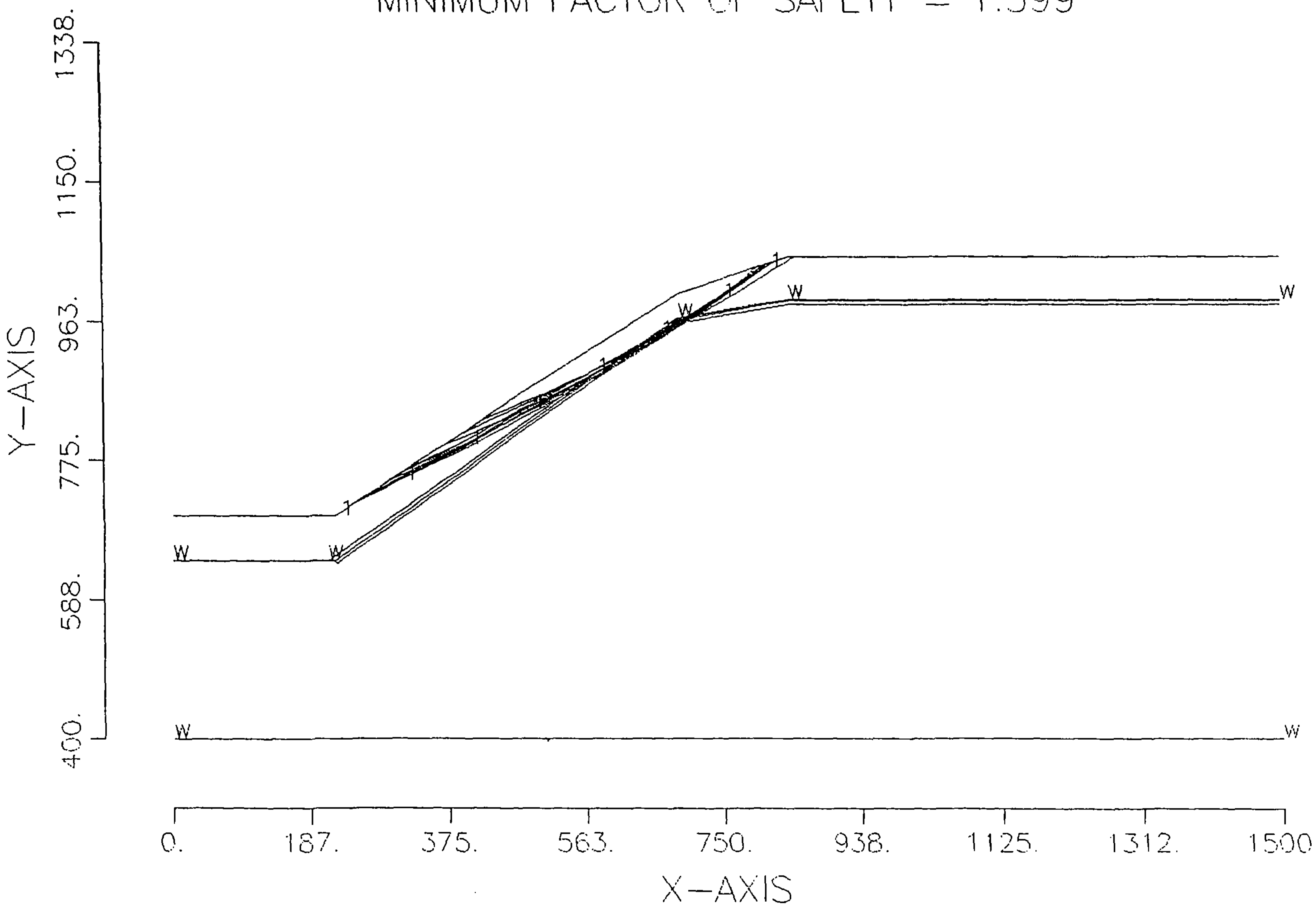
Midvale UT s/n5206

EMPIRE CANYON D–D'

4000SURFACES HAVE BEEN GENERATED

10 MOST CRITICAL OF SURFACES GENERATED

MINIMUM FACTOR OF SAFETY = 1.599



PROBLEM DESCRIPTION EMPIRE CANYON A-A

BOUNDARY COORDINATES

15 TOP BOUNDARIES
19 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	570.00	63.00	575.00	3
2	63.00	575.00	87.00	590.00	3
3	87.00	590.00	108.00	600.00	3
4	108.00	600.00	192.00	610.00	3
5	192.00	610.00	235.00	625.00	3
6	235.00	625.00	300.00	640.00	3
7	300.00	640.00	475.00	717.00	3
8	475.00	717.00	620.00	800.00	3
9	620.00	800.00	647.00	810.00	3
10	647.00	810.00	809.00	919.00	2
11	809.00	919.00	825.00	930.00	1
12	825.00	930.00	835.00	950.00	1
13	835.00	950.00	865.00	950.00	1
14	865.00	950.00	882.00	977.00	1
15	882.00	977.00	1065.00	1010.00	1
16	809.00	919.00	1065.00	928.00	2
17	647.00	810.00	657.00	810.00	3
18	657.00	810.00	810.00	912.00	3
19	810.00	912.00	1065.00	923.00	3

ISOTROPIC SOIL PARAMETERS

3 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	130.0	130.0	475.0	34.0	.00	.0	1
2	130.0	130.0	.0	47.0	.00	.0	1
3	130.0	130.0	.0	47.0	.00	.0	2

ANISOTROPIC STRENGTH PARAMETERS
2 SOIL TYPE(S)

SOIL TYPE 2 IS ANISTROPIC

NUMBER OF DIRECTION RANGES SPECIFIED = 3

DIRECTION RANGE NO.	COUNTERCLOCKWISE DIRECTION LIMIT (DEG)	COHESION INTERCEPT	FRICTION ANGLE (DEG)
1	34.0	.0	47.0
2	36.0	400.0	38.0
3	90.0	.0	47.0

SOIL TYPE 3 IS ANISTROPIC

NUMBER OF DIRECTION RANGES SPECIFIED = 3

DIRECTION RANGE NO.	COUNTERCLOCKWISE DIRECTION LIMIT (DEG)	COHESION INTERCEPT	FRICTION ANGLE (DEG)
1	34.0	.0	47.0
2	36.0	400.0	38.0
3	90.0	.0	47.0

2 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 12 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	570.00
2	63.00	575.00
3	87.00	590.00
4	108.00	600.00
5	192.00	610.00
6	235.00	625.00
7	300.00	640.00
8	475.00	717.00
9	620.00	800.00
10	647.00	810.00
11	823.00	925.00
12	1065.00	933.00

PIEZOMETRIC SURFACE NO. 2 SPECIFIED BY 2 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	500.00
2	1065.00	500.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

4000 TRIAL SURFACES HAVE BEEN GENERATED.

200 SURFACES INITIATE FROM EACH OF 20 POINTS EQUALLY SPACED ALONG THE GROUND SURFACE BETWEEN X = 500.00
AND X = 700.00

EACH SURFACE TERMINATES BETWEEN X = 915.00
AND X =1000.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION

AT WHICH A SURFACE EXTENDS IS Y = .00

50.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

1
AGEC
Midvale UT s/n5206

FAILURE SURFACE # 1 SPECIFIED BY 7 COORDINATE POINTS

SAFETY FACTOR = 1.533

X-CENTER = 286.48
Y-CENTER = 1746.39
RADIUS = 991.11

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	700.00	845.66	26.11
2	744.90	867.66	29.00
3	788.63	891.90	31.89
4	831.09	918.31	34.78
5	872.16	946.83	37.67
6	911.73	977.39	40.56
7	919.10	983.69	

PROBLEM DESCRIPTION EMPIRE CANYON B-B'

BOUNDARY COORDINATES

4 TOP BOUNDARIES
12 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	550.00	270.00	550.00	1
2	270.00	550.00	530.00	650.00	1
3	530.00	650.00	1170.00	950.00	1
4	1170.00	950.00	1500.00	950.00	1
5	.00	490.00	270.00	490.00	3
6	270.00	490.00	530.00	590.00	2
7	530.00	590.00	1170.00	890.00	2
8	1170.00	890.00	1500.00	890.00	2
9	270.00	490.00	270.10	485.00	3
10	270.10	485.00	530.00	585.00	3
11	530.00	585.00	1170.00	885.00	3
12	1170.00	885.00	1500.00	885.00	3

ISOTROPIC SOIL PARAMETERS

3 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	130.0	130.0	475.0	34.0	.00	.0	1
2	130.0	130.0	.0	47.0	.00	.0	1
3	130.0	130.0	.0	47.0	.00	.0	2

ANISOTROPIC STRENGTH PARAMETERS
2 SOIL TYPE(S)

SOIL TYPE 2 IS ANISTROPIC

NUMBER OF DIRECTION RANGES SPECIFIED = 3

DIRECTION RANGE NO.	COUNTERCLOCKWISE DIRECTION LIMIT (DEG)	COHESION INTERCEPT	FRICTION ANGLE (DEG)
1	34.0	.0	47.0
2	36.0	400.0	38.0
3	90.0	.0	47.0

SOIL TYPE 3 IS ANISTROPIC

NUMBER OF DIRECTION RANGES SPECIFIED = 3

DIRECTION RANGE NO.	COUNTERCLOCKWISE DIRECTION LIMIT (DEG)	COHESION INTERCEPT	FRICTION ANGLE (DEG)
1	34.0	.0	47.0
2	36.0	400.0	38.0
3	90.0	.0	47.0

2 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 5 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	492.00
2	270.00	492.00
3	530.00	592.00
4	1170.00	892.00
5	1500.00	892.00

PIEZOMETRIC SURFACE NO. 2 SPECIFIED BY 2 COORDINATE POINTS

POINT	X-WATER	Y-WATER

NO.		
1	.00	400.00
2	1500.00	400.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

4000 TRIAL SURFACES HAVE BEEN GENERATED.

200 SURFACES INITIATE FROM EACH OF 20 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00
AND X = 600.00

EACH SURFACE TERMINATES BETWEEN X =1000.00
AND X =1500.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION AT WHICH A SURFACE EXTENDS IS Y = .00

100.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

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FAILURE SURFACE # 1 SPECIFIED BY 9 COORDINATE POINTS

SAFETY FACTOR = 1.757

X-CENTER = 199.13
Y-CENTER = 2292.01
RADIUS = 1679.65

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	505.26	640.49	12.21
2	603.00	661.63	15.62
3	699.31	688.56	19.03
4	793.84	721.16	22.44
5	886.27	759.34	25.85
6	976.26	802.95	29.27
7	1063.50	851.83	32.68
8	1147.67	905.82	36.09
9	1208.28	950.00	

PROBLEM DESCRIPTION EMPIRE CANYON C-C'

--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION EMPIRE CANYON C-C'

BOUNDARY COORDINATES

4 TOP BOUNDARIES
11 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	620.00	210.00	650.00	1
2	210.00	650.00	670.00	980.00	1
3	670.00	980.00	860.00	1040.00	1
4	860.00	1040.00	1000.00	1060.00	1
5	.00	600.00	210.00	640.00	2
6	210.00	640.00	670.00	970.00	2
7	670.00	970.00	1000.00	1040.00	2
8	.00	570.00	210.00	600.00	3
9	210.00	600.00	670.00	900.00	3
10	670.00	900.00	860.00	960.00	3
11	860.00	960.00	1000.00	980.00	3

ISOTROPIC SOIL PARAMETERS

3 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	130.0	130.0	475.0	34.0	.00	.0	1
2	130.0	130.0	400.0	38.0	.00	.0	1
3	130.0	130.0	400.0	38.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 2 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	400.00
2	1000.00	400.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM
TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

4000 TRIAL SURFACES HAVE BEEN GENERATED.

200 SURFACES INITIATE FROM EACH OF 20 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = 200.00
AND X = 220.00

EACH SURFACE TERMINATES BETWEEN X = 670.00
AND X =1000.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00

140.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL
FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL
FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

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FAILURE SURFACE # 1 SPECIFIED BY 6 COORDINATE POINTS

SAFETY FACTOR = 1.335

X-CENTER = -133.07
Y-CENTER = 1690.41
RADIUS = 1095.32

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	210.53	650.38	21.95
2	340.38	702.70	29.27
3	462.50	771.16	36.60
4	574.89	854.64	43.93
5	675.72	951.77	51.26
6	708.00	992.00	

SAFETY FACTOR = 1.469

X-CENTER = -2153.80
Y-CENTER = 5385.08
RADIUS = 5362.53

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	315.79	625.05	27.96
2	404.12	671.93	29.02
3	491.56	720.45	30.09
4	578.09	770.59	31.16
5	663.66	822.33	32.23
6	748.25	875.66	33.30
7	831.83	930.56	34.37
8	914.38	987.01	35.43
9	972.74	1028.54	

PROBLEM DESCRIPTION EMPIRE CANYON D-D'

BOUNDARY COORDINATES

4 TOP BOUNDARIES
12 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	700.00	220.00	700.00	1
2	220.00	700.00	690.00	1000.00	1
3	690.00	1000.00	840.00	1050.00	1
4	840.00	1050.00	1500.00	1050.00	1
5	.00	640.00	220.00	640.00	3
6	220.00	640.00	690.00	965.00	2
7	690.00	965.00	840.00	990.00	2
8	840.00	990.00	1500.00	990.00	2
9	220.00	640.00	221.00	635.00	3
10	221.00	635.00	690.00	960.00	3
11	690.00	960.00	840.00	985.00	3
12	840.00	985.00	1500.00	985.00	3

ISOTROPIC SOIL PARAMETERS

3 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	130.0	130.0	475.0	34.0	.00	.0	1
2	130.0	130.0	.0	47.0	.00	.0	1
3	130.0	130.0	.0	47.0	.00	.0	2

ANISOTROPIC STRENGTH PARAMETERS
2 SOIL TYPE(S)

SOIL TYPE 2 IS ANISTROPIC

NUMBER OF DIRECTION RANGES SPECIFIED = 3

DIRECTION RANGE NO.	COUNTERCLOCKWISE DIRECTION LIMIT (DEG)	COHESION INTERCEPT	FRICTION ANGLE (DEG)
1	34.0	.0	47.0
2	36.0	400.0	38.0
3	90.0	.0	47.0

SOIL TYPE 3 IS ANISTROPIC

NUMBER OF DIRECTION RANGES SPECIFIED = 3

DIRECTION RANGE NO.	COUNTERCLOCKWISE DIRECTION LIMIT (DEG)	COHESION INTERCEPT	FRICTION ANGLE (DEG)
1	34.0	.0	47.0
2	36.0	400.0	38.0
3	90.0	.0	47.0

2 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 5 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	640.00
2	210.00	640.00
3	690.00	967.00
4	840.00	992.00
5	1500.00	992.00

PIEZOMETRIC SURFACE NO. 2 SPECIFIED BY 2 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	400.00
2	1500.00	400.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM
TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

4000 TRIAL SURFACES HAVE BEEN GENERATED.

200 SURFACES INITIATE FROM EACH OF 20 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00
AND X = 500.00

EACH SURFACE TERMINATES BETWEEN X = 800.00
AND X =1500.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION AT WHICH A SURFACE EXTENDS IS Y = .00

100.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

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FAILURE SURFACE # 1 SPECIFIED BY 8 COORDINATE POINTS

SAFETY FACTOR = 1.599

X-CENTER = -3310.95

Y-CENTER = 7643.34

RADIUS = 7787.66

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	236.84	710.75	27.47
2	325.57	756.88	28.20
3	413.69	804.14	28.94
4	501.21	852.53	29.68
5	588.09	902.04	30.41
6	674.33	952.66	31.15
7	759.91	1004.39	31.88
8	825.44	1045.15	